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LIFE AND SENSE

STUDIES

IN

LIFE AND SENSE.

I.

HUMAN RESEMBLANCES TO LOWER LIFE.

"It is dangerous to show man how much he resembles the beasts, without at the same time pointing out to him his own greatness. It is also dangerous to show him his greatness, without pointing out his baseness. It is more dangerous still to leave him in ignorance of both. But it is greatly for his advantage to have both set before him." So far, Pascal in the "Pensées." There is a considerable deal of sound philosophy in these words. Whilst we might legitimately enough object to the term "baseness" as above used to indicate comparatively the gulf betwixt man and his lower neighbours, the conclusion of Pascal's meditation may sufficiently satisfy both the moralist and the student of science. That which Pascal declares is greatly to our advantage—namely, to have both man's likeness to, and differences from, lower animals duly set before us—is in a fair way of being realised in these latter days. Biological science, which was formerly regarded as closing its investigations when it approached the human domain, has now boldly entered the precincts of man's own and special order. In a sphere within which biology was formerly regarded as an intruder, it is now welcomed by the latest culture as a friend. As a race, we are beginning to overcome, by an exercise of robust common sense, the feeble foibles and objections which in the early days of Mr. Darwin's fame were urged against any approaches on the part of our "poor relations." The social prejudices which still exist here and there, and which are engendered chiefly by popular studies of quadrumanous manners at the Zoo', have died away in sensible and unprejudiced minds. The great discovery—only made, it should be added, after nearly a quarter of a century of misconception—that Mr. Darwin and his friends did not

recognise in the gorilla or orang even a far-off cousin of humanity, brought a sense of deep consolation and comfort to many minds. The additional statement that the kinship between man and apes was limited to an ancient connection placed very far back on the tree of life, and existent long before men were men, or even respectable monkeyhood had appeared, conveyed still deeper satisfaction to those who sympathised with the opening expression we have quoted from the "Pensées." Willing to concede that humanity was certainly nearer the quadruped races at large than had been previously suspected, the thoughtful amongst us began at the same time to perceive clearly enough that the conclusions of Darwinism, after all, only tended to throw human characteristics into bolder relief, against the lower substratum on which these traits are founded. Recognising the animal basis, so to speak, it was seen that all in humanity's own sphere which was worth extolling and valuing had been left unaffected by the bath of evolution through which the nature of mankind had been passed.

The attitude of objectors to the scientific exposition of man's place in nature has thus undergone a material change. It is no longer deemed heretical to assert our near relations with the quadruped-stock; and no social ostracism is involved in the intelligent acceptation of even the furthest conclusions advanced by the upholders of the theory of evolution. There are not a few persons, in truth, who, at first alarmed by the apparently incongruous declarations of man's kinship with lower forms, expected a fearful fall from the secure position of human dignity; such persons, to quote Mr. Leslie Stephen's remark, having found that, after all, they were hanging not on the brink of a vast precipice, but merely from a rocky ledge with the toes, all unknown to themselves, nearly touching the ground. And we have heard of still more cheerfully disposed people, who, finding, to their relief, that humanity and its affairs remained perfectly undisturbed by Mr. Darwin's views, became converted to scientific ways of thinking, and even contrived to find a cheering proof of man's lower kinship in the metaphorical declaration of Job that man is the descendant of the worm.

But if the general opinion that, after all, evolution is by no means such a dreadful conception as was formerly supposed, has rapidly gained ground amongst us, there yet remains a considerable lack of information concerning the exact fashion in which man's resemblance to lower forms of life are demonstrated by nature. Objections to the views of science on this hand, proceed as often as not from inability to comprehend the relationships which, apart from all theories, actually exist between man and other animals. The knowledge of these relationships lies in a perfectly elementary study of natural history. There need be no difficulty in the ready comprehension of

the chief points involved in such a study. Just as the comparative psychologist can point to mental traits which no one denies are common to man and lower animals, so the anatomist can demonstrate a like connection between the bodily belongings of humanity and lower tribes of living beings. Resemblances in mind are, in truth, paralleled by likenesses in body between the human and lower estates, which are even more convincing in their demonstration of our natural kinships than the traits of mental life.

One of the earliest fruits of the labours of Cuvier consisted in the demonstration of the fact, that, viewed by the science of his day, no animal had a type or plan of body peculiar to itself, but, on the other hand, presented a striking similarity in its general structure to a greater or less number of other animal forms. There might be no actual likeness perceptible between two animals, or two groups, or there might exist differences apparently so great and so palpable that their disagreement in nature could be readily prophesied; and yet, it could be shown, as Cuvier demonstrated, that underlying the obvious dissimilarity of outward details, there might be found a more obvious and more striking community and likeness of type. Now, that which Cuvier demonstrated at the beginning of the present century, still remains a sure article of zoological faith. That is to say, we are aware that no animal has a type or build of body peculiar to itself. Any animal we care to select from the varied array of the children of life must fall into one or other of certain broad groups or types, whereof Cuvier laid for us the solid outlines and foundations. It is true that naturalists may not agree concerning the exact number or constitution of their "types" of animals; and it is likewise correct to affirm that the limits of these "types" have been frequently changed, and are even now altered and revised, like the boundaries of parishes and electoral districts, to suit the exigencies of increasing wisdom. But Cuvier's main principle stands practically where it did at the beginning of our century, and certain of his original "types" represent, with comparatively little change, the existing and received constitution of the animal world, as defined by the zoological science of to-day. It is a striking enough fact, that the apparently endless variety of form we behold in a great museum of zoology should be capable of being arranged in a certain, and by no means large, number of "types." Yet that such is the case is readily enough proved; and it will be found that the appreciation of this wholesome zoological truth renders the position of humanity in the animal series a matter of very clear and unmistakable definition.

A shrimp and a butterfly are animals, which, in respect of the dissimilarities in their appearance, habits, and presumably in structure as well, present us with two types, apparently as diverse in nature as could well be selected from the zoological series. The

comparatively slow movements of the shrimp contrast forcibly with the aërial life of the insect, and the points of likeness might, indeed, be assumed to be non-existent for the non-technical mind. An examination of shrimp anatomy would reveal much that was interesting and curious in the way of animal belongings. The appendages of the body, for example, which begin with the big, compound eyes on their movable stalks, as we pass backwards become first jaws, then jaw-feet, and legs, and finally end by appearing as the curious flappers or "swimmerets" of the tail. These appendages, therefore, present us with a curious study in Nature's ways of adapting one and the same type of organ to an amazing variety of uses. Then, we should note also, that the shrimp-body, which seems all head and tail, is really resolvable into a head and chest united firmly together, and a jointed tail ending in the broad tail-fin. We should further observe our shrimp to be built like the steamships of to-day, in "compartments" so to speak, or in "joints" to the number of twenty or so. An inquiry into the internal constitution of shrimp existence would reveal the fact that the cuirassed hopper of our sands is well provided with the organs and possessions through which life of a type much higher than his own is maintained. He possesses a heart situated in his back; a digestive apparatus, including a stomach, liver, and intestine, occupying the middle line of his body; and a nervous system, consisting typically of a double chain of nerves and nerve-masses, lying on the floor of his frame. So far, then, shrimp existence appears to be well provided in the matter of organs and parts necessary for the maintenance of its by no means inactive life. We may perceive in the arrangement of parts just described—the heart on the back, the digestive system in the middle of the body, and the nervous system below—something more than an accidental occurrence. On the contrary, it would require no special gift of prophecy, scientific or otherwise, to predict that all other shrimps, and all lobsters and crabs likewise, not to speak of the hundreds of lower relations of the shrimp class—water fleas, barnacles, and the like—would possess an essentially similar arrangement of their parts. Actual examination of the animals just named would show us that our prophecy was founded, according to the advice of Hosea Biglow, on an actual knowledge of affairs. The whole shrimp-race and the varied tribes of crabs, lobsters, and lower crustaceans, are built on one and the same plan, namely, on that seen in the familiar denizens of our sandy reaches.

But a further thought will unquestionably suggest itself, namely, whether or not this type or build of body is peculiar to the shrimp class and its neighbours. To answer this query, we may profitably enough, perhaps, turn to our butterfly; a quest which, at first sight, certainly seems anything but promising in its nature. The know-

ledge of butterfly-anatomy, however, soon dispels any doubts one may have entertained regarding the relationship of the insect with the shrimp. For we discover, firstly, that the body of the butterfly is constructed of segments or joints, corresponding in structure, as they practically agree in number also, with those of the shrimp. Again, the appendages of the butterfly, though specially modified for its aërial life and for its work of flower-visitation, present us with a type which is essentially that seen in the curious jaws, jaw-feet, and legs of the armoured crustacean. Lastly, but by no means the least convincing proof of the unity of type which underlies the apparent dissimilarity in form and life, we find the personal belongings of the butterfly to present us with an exactly similar arrangement to that seen in the shrimp. The insect-heart pulsates just beneath the covering of its back; the digestive system occupies the middle region of its frame; and the nervous system, presenting us again with the double-chain type, lies along the floor of the insect-body. Not only does our discovery of the remarkable similarity of type teach us that the Crustacean host and all butterflies possess bodies which are built up on one and the same type, but we also learn that what holds true of the relations of one shrimp to others and to all its neighbour crustaceans is likewise true when we consider how butterflies are related to their insect neighbours. Each one of the thousands of existing insect species presents us with a body essentially similar to that of our butterfly in its broad details. Where differences exist, they are referable to the modifications of one and the same plan, and are not produced by the inauguration of new plans or fresh types. All insects are therefore found to be modelled on the type we discover underlying the butterfly's personal anatomy. It is therefore no transcendental dream, but a sober fact of zoology, that by constructing the figure of a jointed animal with its appendages, with a back-heart, a nervous system below, and a digestive tube running through the middle of its body, we should represent the archetype, so to speak, at once of the insect class and of the crustacean tribes. Furthermore, it would be easy to add other important facts which rest on a similar basis to those just described. All worms, spiders, mites and scorpions, and centipedes, conform to the plain archetype we see in shrimp and butterfly. So that when, to return to Cuvierian axioms, we speak of the "Articulated" or "Annulose" animals, forming one of the chief and primary divisions or "types" into which the animal kingdom has been parcelled out by Nature, we are only reiterating the facts taught us by our examination of the shrimp and butterfly. One and the same fundamental idea is thus found to underlie the often wide dissimilarities of animal life; and it is puzzling to say whether we are most liable to be struck by the unity which prevails beneath the diversity of the animal

forms just noted, or by the countless modifications into which one and the same plan, has, undoubtedly, through the ages of the past, been evolved.

This digression into the regions of lower life has fitted us for a profitable return to the domain which claims humanity as the flower of its flock. Man's frame, the most complex which the anatomist knows, is commonly believed to be constructed on a type peculiar to itself. It is, at least, a matter of common belief that we stand on a structural platform that is peculiarly our own. It is this tacit belief which causes us to regard any obvious approach to our own structure and conformation—as in the apes, for example—in the light of a natural burlesque, rather than as a sober reality, depending upon causes and laws written unmistakably in the constitution of living things. Yet there is no truth further removed from the region of fiction or hypothesis, than that which asserts that man has no type peculiar to himself, any more than a shrimp or butterfly possesses a bodily plan essentially and peculiarly its own. On the contrary, we see in the human frame, merely the most specialised and distinct form of a particular type or plan, which agrees in its broad details, as a plan, with that seen in every fish, frog, reptile, bird, and quadruped or mammal. Humanity rears its head erect at the top of the animal tree, but it exists after all only at the end of its own particular branch, which we know scientifically as the Vertebrata, or, familiarly, as the "backboned" type. Every feature which, in man, is to be regarded as most purely distinctive and human in its nature, can be shown to represent simply the extreme development or modification of characters or organs belonging to the type as a whole. From man's liver to his brain, from the bones of his wrist to the structure of his eye, there is nothing to be found that is not foreshadowed in type in the quadruped class, or even in lower vertebrates still. Later on we shall have occasion to show that, as Mr. Darwin remarks, man bears in his body undeniable traces of his lowly origin. So that those philosophers who may feel inclined to grumble at the clear evidences which anatomy presents of man's relationship to, and place in, a great common type of animal life, will require, after all, to bear a grudge not against the anatomist, but against Nature herself, and against the constitution of the animal world. It is hardly worth our while in truth to feel aggrieved, for example, at the knowledge that the highest apes possess a hand which, bone for bone and muscle for muscle, resembles our own in type, when we discover that man's "third eyelid"—existing in a rudimentary state—is in reality a relic of a complete structure, possessed by animals as low down in the vertebrate scale as the fishes. If we are to be unphilosophical enough to consider questions of dignity, when some obvious resemblance between ourselves and our nearest

neighbours, the quadrupeds, is pointed out, we must be bordering on despair when zoology teaches us the plain fact that, as regards the general type of our body, it is that common alike to fish, frog, reptile, fowl, and quadruped. If we are to wring our hands because it is suggested that man's place in nature is seriously impugned by the revelations of zoology concerning his near alliance with other quadrupeds, we should be prepared to clothe ourselves in sackcloth when the truth creeps out, that not merely are our bodies built up on the common "backboned" plan, but that the bones in the body and limbs of frog, reptile, and bird, find their obvious reflex in the skeleton of creation's lord.

Suppose, for example, that we examine the body of a fish. We find its nervous system—brain and spinal marrow—enwrapt within a bony tube, formed by the skull and spine—the latter chain of bones forming, as every one is aware, a salient feature of vertebrate life at large. The nervous system, just noted, is further observed to lie in the back region of the animal. The digestive apparatus of the fish, again, is situated in the middle line of its body, whilst the heart lies lowest as the fish swims. Above the digestive system, and below the spine, we should lastly find a second nervous system, named the "sympathetic." This latter apparatus consists essentially of a double chain of nerves and nerve-masses, and reminds us somewhat of the nervous belongings of the shrimp and butterfly. Now this disposition of matters, it need hardly be remarked, is peculiar to no one fish. It is seen in its plain details in every member of that class, here and there showing elaboration, or, on the other hand, exhibiting simplification, but preserving intact throughout, all the essentials which constitute it a veritable type or plan. The frog-class exhibits a like build of body. Every frog or newt resembles the fishes in the placing of its nervous system, in the situation of its heart, in the constitution of its spine, digestive apparatus, and sympathetic nerves. So also with the cold-blooded reptiles, and with the warm-blooded birds. However far removed these animals may appear to be from the fish, the one type seen in the latter, remains as that which is paramount in the denizens of earth and air. And, last of all, coming to the quadrupeds or mammals, highest of the children of life, we can discern in them the same build of body seen in fish and fowl. We discover that man, in virtue of all his characters, falls naturally to be included within the quadruped class, and remains as at once "the paragon of animals," and head of this group. In this position, man is, therefore, an undoubted "mammal," and shares firstly all the purely essential characters of the group, with forms so lowly as the "duck-billed water-mole" (*Ornithorhynchus*) of Australia, or its neighbours the kangaroos, and also with mammals of highly elaborated nature, such as the bats and the apes. But along with the host of

mammals, man also exhibits a community of broad type and plan, which demonstrates that in the build of his body he is at one with even fish and frog. There is no escape from this plain, healthy recognition of "man's place in nature." So far, therefore, from our being able to discover within the sphere of humanity any special possessions which entitle man to claim a structural kingdom for himself, we see, on the contrary, that he simply shares a position in the animal world to which every other "backboned" form has a legitimate claim. His more special features are, in reality, the outcome and elaboration of traits which lower life exhibits in germ form long before the human domain is reached. So that, whilst man stands a veritable "lord of the creation," he truly occupies this elevated niche only because he represents in himself the concentrated and elaborated development of the type and belongings of existences infinitely lower than his own.

Turning now to the investigation of more minute and specialised points wherein the resemblances which exist between man and lower forms may be more distinctly seen, we may first enter that region of comparative anatomy which has for its aim the investigation of what have been named "rudimentary organs." In former decades of natural history study, biologists were not given to trouble themselves concerning the existence or nature of such parts. In truth, the existence of many rudimentary organs in animals and plants has only been brought to light as a relatively recent discovery in biology. The naturalists of old, with very special views of teleology and creation before their eyes, were given to discuss in detail the uses and purposes of the various organs and parts of living beings. Nowadays, we are quite as much concerned with the study of the "purposelessness" of certain parts, as with the evident functions of others. A philosophy of by no means shallow character, but which, on the other hand, lies at the root and foundation of our modern theory of nature, is bound up with this study of parts which have become purposeless and useless. It is the idea that they have *become* so, that in reality constitutes the gist of the philosophy which explains their being; since on all other theories of their existence, the presence of useless and degenerated organs in animals and plants constitutes an unexplained mystery of life.

That humanity possesses within the compass of its frame a considerable number of examples of useless parts, which, as G. H. Lewes remarked, have a reference "to a former state of things," is readily proved. If, for instance, we make a superficial examination of the muscular surroundings of the human ear, we may discover certain plain examples of the rudimentary organs, to which the modern anatomist attaches a high importance as clues and guides to the past history of the race that exhibits them. The power to move our ears is, of course, non-existent in the vast majority of mankind. Now

and then we meet with an individual who can fulfil one of Lord Dundreary's tests of superiority in that he "can wag his left ear," and can move his right ear also. At will, such individuals can produce feeble though distinct movements of the ear. This power depends upon an unusual development of muscles which, in ordinary individuals, exist in a rudimentary state. The ability to move the ear is held to be a relic of a power once well developed in the ancestry from which the human race has sprung. Darwin tells us that he saw "one man who could draw the whole ear forwards; other men," he continues, "can draw it upwards," another "could draw it backwards;" and, adds Mr. Darwin, "from what one of these persons told me, it is probable that most of us, by often touching our ears, and thus directing our attention towards them, could recover some power of movement by repeated trials." Three little muscles, named in anatomy the *attolens*, *attrahens*, and *retrahens aurem*, respectively (or the "raiser," "forward-drawer," and "back-drawer" of the ear), are found associated with the outer ear in man. They are so small as to be useless for any purpose of ear-movement, as we have seen; but that their former and ancestral function was that of moving the ears admits of no question. In lower animals, we find corresponding muscles well developed; whilst we may also discover additional muscles to be represented in the belongings of the ears of many quadrupeds. In the ear of the horse there are such additional muscles; and we can readily conceive that the wonderful pliability and range of movement of the outer ear in this and other animals would demand an increased muscular supply over that found in higher quadruped life, where ear-movement becomes of less importance than in lower existence. Thus we discover that in such apes as the chimpanzee and orang, whose ears closely resemble those of man in form, the ear-muscles are well-nigh as feebly developed as in the human subject; and the ears of these animals do not appear to be capable of any greater range of movement than is exhibited by man.

But the ear-muscles do not constitute the only muscular anomalies to be found within the human domain. In the belongings of man's nose are to be found certain feeble or useless muscles, which are, however, well developed in lower quadrupeds. For example, there exist within the confines of human anatomy, muscles which can partially close our nostrils. The complete command of these muscles over the nostrils has been lost; but in such an animal as the seal, which in diving requires to close its nostrils firmly against the entrance of water, the corresponding muscles are very largely developed. Another interesting peculiarity of our muscular system consists in the comparatively feeble and rudimentary development of these muscles, which belong to the category of so-called "skin-muscles." These latter organs derive their name from the fact that they possess

a special action on the skin and superficial parts or appendages which the skin may develop. In man, what is known as "goose-skin," results from fear, or, it may be, from the effects of cold. The little papillæ of the skin stand out more prominently in consequence of the contraction of minute muscles. When the hair "stands on end," the phenomenon is due to a similar cause, namely, the action of the small muscles attached to the hair-sacs. In birds these muscles are found to be very largely developed, and are used for the erection and depression of the feathers; so that it forms a curious but veritable truth of biology, that the symptoms of fright in humankind simply form an exhibition of feeble and diminished powers which are seen in the full flush of their development in birds and in other vertebrates.

But the list of the skin-muscles, which man possesses in a rudimentary state as legacies from a far back ancestry, is by no means exhausted, or even fully illustrated by the foregoing observations. There are two muscles in man which have always excited attention from their anomalous nature. The one muscle is called the *occipito-frontalis*, and may be described as the great scalp-muscle, through the action of which certain persons are able to move the hairy scalp backwards and forwards with great rapidity. Ordinarily, we use this muscle to wrinkle our eyebrows, and to raise the eyebrows in the act of expressing surprise. Whoever has seen a Macaque monkey in a rage will require no further illustration of the fact that the power of movement in the muscle just named is possessed in all its typical development by the quadrumanous tribes. In the monkeys, the brow can be deeply wrinkled, and the scalp is made to contract under the influence of emotion with singular dexterity. It is curious to observe that the power possessed by some human beings over their scalps is capable of being transmitted, like other features of bodily organisation, to posterity. Such a fact illustrates very powerfully the innate and intrinsic nature of the powers in question. Mr. Darwin tells us that M. A. de Candolle communicated to him a very typical case of the transmission and inheritance of an unusual power of using the scalp-muscle. The head of a family, when a youth, could pitch several heavy books from his head by the movement of the scalp alone; and he won wagers by performing this feat. His father, uncle, grandfather, and his three children, possess the same power to the same unusual degree. This family became divided eight generations ago into two branches; "so that the head of the above-mentioned branch is cousin in the seventh degree to the head of the other branch. This distinct cousin resides in another part of France, and on being asked whether he possessed the same faculty, immediately exhibited his power." The transmission of such a peculiarity merely illustrates

the existence of that variation in living beings to which we owe all our supremacy over lower forms. Acting in one fashion, it is this variation, aided by use and "selection," which deprives us of the powers possessed by the muscles of lower life. In another aspect of its operation, it is this same principle of variation which, acting through "reversion" or the return to former and lower states, renews, within the children of light and leading, the traits of the ancestry of those far back æons when the world of life was but in its teens.

More extraordinary still, is the history of the second of the "skin-muscles," to which allusion has been made. In lower animals is found a peculiar muscle which rejoices in the name of the *panniculus carnosus*. When we see a lively porpoise disporting itself in the waves, rolling head over heels, and otherwise exhibiting that propensity for aquatic gambols which is a characteristic of its race, we may credit the muscle just named, with a full share of work in producing the movements of the lithe fish-like frame. It would not be incorrect to describe the body of the porpoise as being literally swathed in this great muscle, so thoroughly developed are its proportions in that animal. When that modest but bristly quadruped the hedgehog contrives in a moment of surprise to roll head and tail together, and to present an impregnable surface to the gaze of his enemy, human or canine, as the case may be, we must credit his "panniculus" with the work of suddenly transforming him from an active quadruped into an inanimate ball of spines. A dissection of a hedgehog would show us that the great skin-muscle can be split into nine pairs of muscles, and that one of these pairs represents the "scalp-muscle" of humanity. Or again, when we see the horse "shaking his coat," or the retriever dog which has just left the sea, sending the water from off his skin in the effective fashion of his race, we are simply witnessing the action of the "panniculus"-muscle in another phase of its action.

Ascending now to humanity, how, let us inquire, is the "panniculus" developed in man, and what are the functions it can be shown to possess? As our previous studies will have led us to expect, the "panniculus" of man exists, firstly, in a condition which may truly be described as "rudimentary" when compared with its development in lower life. The "scalp-muscle" has just been noted to represent part of the "panniculus," which in man thus becomes split up into separate and detached portions. Another part of the great "skin-muscle" of the hedgehog is found in that muscle which in human anatomy receives the name of the *platysma*. This latter muscle exists as a broad sheet of fibres, lying just beneath the skin on each side of the neck. In man it serves to wrinkle the skin of the neck, and it also aids in depressing the lower jaw. In other parts of man's body, traces of the division of

the "panniculus" are also to be found. In the proportion of about three per cent. in upwards of 600 bodies examined, Professor Turner tells us that a muscle of man's trunk, usually regarded by anatomists as of ordinary type, is really a fragment of the great "skin-muscle." Again, a curious muscle in man, known as the *palmaris brevis*, lying imbedded in the fat of the inner or little finger side of the palm of the hand, and which passes to be attached to the skin covering the ball of the little finger, is to be regarded as a relic of the skin-muscle of lower life. This muscle also occurs in the lemurs, and is found even in the kangaroo order. It may therefore represent a very early development of the "skin-muscle," which became separated from the great bulk of that structure long before the other portions assumed a distinct individuality. So far, therefore, as man's muscular arrangements are concerned, he may be said to exhibit no peculiarities which cannot be accounted for on grounds compatible with the belief that his most characteristic belongings represent either special developments, or on the other hand degenerations, of the fibres of lower forms.

From the "skin-muscles" and face to the eye is but a brief step; and in certain structures connected with the organ of sight in man we may discover other links relating man to lower life. The "third eyelid" of animal life has already been cursorily alluded to. This structure is the "nictitating membrane" of comparative anatomists. As low down in the vertebrate series as the sharks, this curious structure is to be found; amongst the frogs and reptiles it is far from uncommon; and in birds it assumes a high prominence amongst the belongings of the eye. Amongst the quadrupeds, it occasionally exhibits a tolerable development. In the walrus, for instance, it is seen in perfection, whilst amongst the lowest mammals—the kangaroo order and that of the "duck-billed water mole" of Australia—it is specially developed. Of higher quadruped life as a whole, the "third eyelid," however, cannot be said to be characteristic. In the birds, in which the "third eyelid" is specially developed, this structure exists as a membrane which sweeps across the surface of the eyeball from the inner to the outer side, somewhat after the fashion of a shutter. In many birds, this eyelid is of a white hue, in others it is transparent. Two special muscles assist its movements. These muscles pull the eyelid over the globe of the eye, and upon their relaxing their action, the membrane returns through its own elasticity to the inner corner of the eye-cavity, where it lies folded until again called into use. In man and the apes, no third eyelid is developed; a feature in which they agree with the great bulk of the quadrupeds. But when the eyes of man and his nearest allies are carefully examined, a curious, little, half-moon-shaped fold (*plica semilunaris*) is seen to exist at the inner corner of the eye-border. Between the two layers of which this little fold is composed, there is developed a

small plate of cartilaginous gristle. Traced backwards to the antecedents which it owns, this fold is seen to represent the third eyelid in a degraded and deteriorated condition. From its highly developed shutter-like function in birds, where it sweeps over the eye-surface and cleanses the globe from foreign bodies, or from its development amongst lower quadrupeds, to the degradation it exhibits even before the sphere of humanity is approached, many links of the chain may be wanting in truth. But for the mind of the anatomist there remains only one natural explanation of the occurrence of the useless fold in the corner of the human eye. Like the rudimentary ear-muscles, it carries us in imagination to a far back past, when, in the pre-human ancestry, the third eyelid possessed functions as important as that exhibited by its representative in the bird to-day.

The teeth of animals form a series of structures, subject, as even the tyro in zoology knows, to literally immense variations, which bear, as a rule, a relation to the habits of life of their possessors. Man's teeth are undoubtedly peculiar in that they form a continuous series, and are not separated throughout their extent in either jaw by an interval, such as we see very familiarly in the mouth of a horse or rat. It is true that man shares this peculiarity with a little lemur called *Tarsius*, and with an extinct quadruped the *Anoplotherium*; this fact serving naturally to diminish somewhat the special character of the human teeth-array. The "eye-teeth," or "canines" of humanity, although not specially prominent, are yet sufficiently developed to prove that they have assumed their present place in the jaw only by protest, as it were, and that at no very remote period they were much more obtrusive than now. In the apes, we see these teeth highly developed, reminding us of their prominence in the carnivorous tribes. So also, when man sneers, he uncovers his upper canine of one side, after the fashion of the enraged dog, and employs similar muscles for the display of the tooth. Mr. Darwin is, therefore, speaking within the bounds of a scientific philosophy when we find him saying that a sneer reveals the animal descent of man; "for no one," he continues, "even if rolling on the ground in a deadly grapple with an enemy, and attempting to bite him, would try to use his canine teeth more than his other teeth. We may readily believe from our affinity to the anthropomorphous (or manlike) apes that our male semi-human progenitors possessed great canine teeth, and men are now occasionally born having them of unusually large size, with interspaces in the opposite jaw for their reception. We may further suspect," concludes Mr. Darwin, "notwithstanding that we have no support from analogy, that our semi-human progenitors uncovered their canine teeth when prepared for battle, as we still do when feeling ferocious, or when merely sneering at or defying some one, without any intention of making a real attack with

our teeth." In other words, the mere gesture, once probably pursuing a very definite use in the battle of attack, has, like the tooth concerned in its exhibition, become a mere shadow of former realities. Other teeth, besides the canines in man, appear to afford means of tracing his kinship with lower forms. That the last molar, or "wisdom" teeth, are probably smaller in the men of to-day than in the races of the past, appears to be a credible assertion. That the last molars are becoming rudimentary, and are tending to disappear in civilised races of men, is a well ascertained fact. Contrariwise, it is in savage races that these teeth are found in perfect development, just as, in lower men, the *intermaxillary bone* of animals is found occasionally to be represented. The wisdom teeth appear to be of larger size in those races of men whom we justly esteem of lower nature than ourselves; and if this observation be correct, it would appear to show that our dental belongings, like our muscles, are not beyond the reach of those modifications to which we owe, in part at least, our ascent from lower ancestry to the crown and acme of life's development.

The race of jokers who, once upon a time, were fond of levelling caustic remarks at the evolutionists' beliefs were accustomed to find great comfort and consolation, amidst possible troubles engendered by the thought of a low human ancestry, in the consideration that man at least wanted one characteristic trait of lower life in the shape of a tail. The hopes of the perturbed were somewhat shaken by the discovery that, firstly, as man certainly possesses four rudimentary tail-vertebræ tacked on to the extremity of his spine, Lord Monboddo's supposition concerning the disappearance of the caudal appendage of humanity, might, after all, be more tenable than was generally supposed. It was something, at least, to have discovered that humanity still possesses the rudiment of a tail, and that the question was not one of "tail or no tail," but the more important question of the why and how of the tail's disappearance. The magot, or Barbary ape, has fewer bones in his "tail" than man; and of course the highest apes—gorilla, chimpanzee, orang, and gibbon—possess a tail no longer than is found in humanity, whilst the "tail-muscles," as in man, are rudimentary or altogether wanting.

The disappearance of a tail is not, however, limited to quadruped life. A crab's tail, well developed in the young state, grows "small by degrees and beautifully less," until it becomes tucked up under the head and chest, and forms the well-known "purse" of that familiar crustacean. On this ground alone, the crab might claim to rank as a higher and more modified animal than its tailed neighbour the lobster. Similarly, the tailed tadpole develops into the tailless frog, which is undoubtedly a more specialised animal than its near neighbour the tailed newt.

Passing backwards in animal history, we discover that the true story of living beings is often to be compiled by the aid of development alone. In truth, the investigation of tails as they are, reveals very little about tails as they were. We may safely apprehend that the human tail represents a degenerate appendage. It remains for development to show us that our supposition implies a fact. If we trace human individual history backwards to a period very early in the development of our frame, we shall find that the extremity of the spine is not only a very prominent feature in human anatomy, but projects distinctly beyond the lower extremities. The human tail in an early stage of our development, is, in fact, twice as long as the legs. At the corresponding period in the development of the highest apes, the tail is equally prominent. As development advances, however, the caudal extremity begins to decline, and comes to assume its human characters, or rather to assume these features which, in this respect, man shares with the higher apes. Only in rare cases, does the "tail" persist in its early condition, and in such instances the individual is born in possession of an external rudiment of a caudal appendage. In the degraded "tail" of normal humanity, the rudiment of the "extensor" muscle of the tail is, however, still to be found; this muscle linking us to the lower stages, in which the tail-movements are a characteristic feature of life. Curiously enough, at the tip of the human tail, there is known to exist a very singular structure, the exact nature of which was for long doubtful. But as this structure was believed to correspond to the tail-bloodvessel in a modified condition, search was made for a similar structure in lower life, with the result that in the cat and in a Macaque monkey, a similar body was found, although in these animals it was not situated as in man, at the extremity of the appendage. The occurrence of such a body in a true and well-developed tail shows how clearly the terminal point of man's spine falls within the category of "caudal" structures.

One of the most striking features of human anatomy leads us to investigate very briefly the structure of the intestine, which, as every reader knows, is simply the digestive tube continued onwards from the stomach. The digestive system of any animal may in fact be described as a tube, whereof the stomach itself is merely a distended part. In most animals, the intestine can be divided into a "small" and "large" portion; the former becoming continuous with the latter. At the junction of the small and large intestine of humanity, there is found a pocket-like portion, forming, in fact, the first part of the large intestine, named the *cæcum*. Attached to and opening from this pocket, is a small tubular appendage, which, at first sight, suggests a structure of rudimentary and useless kind. That the cœcum itself is of rudimentary kind in man, is

readily provable. In the hare or horse it assumes an immense size, and it is very large likewise in that near neighbour of the kangaroos, the koala. The explanation of the small cœcum of man and its tubular appendage appears to be readily found, when we take into consideration the development of this structure in lower life. Even in some lemurs, these lower kith and kin of the monkeys, the cœcum is large and yet possesses the tubular addendum; a fact showing us that probably the extremity of the cœcum first degenerates, and that the cœcum itself lastly becomes rudimentary as a whole. Occasionally, in man, the tubular appendage of this part of the intestine may present us with a tolerable development; Nature in such a case reverting to the primitive condition. But as it exists normally in man and the apes, we simply see in this modified part of the digestive apparatus an additional proof of the work of variation as that process has operated in the production of the highest forms of quadruped life.

Allied in its nature to the foregoing modification seen in the production of man's frame, is another characteristic, wherein bone and bloodvessel unite to produce a feature of higher existence. In the bone called the *humerus*, which forms the single bone of the upper arm in man, there is occasionally found a distinct passage through which pass the great nerve and artery of the fore-arm. In the normal and usual condition of the bone, a mere trace of the passage in question exists; but it becomes interesting to note that the abnormal in man is the normal in lower life. That is to say, even certain of the monkeys, not to speak of carnivorous animals and the kangaroo tribe, possess the passage in its complete state for protecting the artery and nerve of the lower part of the forelimb. Occurring, as it occasionally does, in man, we see in the presence of this passage another proof of reversion to a lower ancestry. So also, another passage in the same bone is now and then seen in man, and is a constant possession of lower quadrupeds, and often of some monkeys. But the curious fact remains, that in the men of old, and in primitive races, this latter passage was a very constant feature. The plain inference seems to be that ancient man, standing nearer to the animal ancestors of his race, naturally exhibited in fuller details the belongings of his ancestry; just, indeed, as Professor Owen remarks, that the muscles of the human ear, already discussed, "probably existed in normal size and force" in the primitive men of the stone period.

The early stages of human development, and the first beginnings, so to speak, of the individual frame, present to the eye of science certain very marvellous proofs of man's kinship with lower life. Away backwards in the dim ancestral periods, when the lower types were evincing their special tendencies towards the evolution of the

"paragon of animals," the evidences of that lower life gradually began to pale and to disappear, as first the pre-human, and then the human, characters were outlined. The projecting face-bones, still seen to-day as a lingering survival in lower races of men, began to be compressed and concentrated, as the work of making the "human face divine" with its overhanging brain proceeded apace. The massive teeth and muscles of lower life were gradually modified to form the more modest structures our race exhibits to-day; and the erect posture, sustained without an effort, likewise began to be assumed as a special feature of the developing tribes of humanity. This much we can see by the lawful scientific use of the imagination in a backward glance along the lines of the past. It would appear to the eye of the biologist as though the human characters had been laid over the features of the lower life that preceded them—as if the picture of humanity's progress had been painted over and upon the design which the cumulative life of the vertebrate had furnished as a foundation for the best and highest work of all. If such a simile holds good, we might expect, in examining closely the latest figures on the canvas, that here and there we should obtain a glimpse of the artist's first outlines, and of the preliminary sketches which served for the realisation of the more perfect ideal. As from the erasures and blots of the finished manuscript, we may gain a clue to the genesis of th writer's thoughts, so we may read between the lines of the warp and woof of life, and may detect occasional glimpses of the fashioning of lower types into that of humanity itself. The glimpses we do obtain, are often blurred and indistinct, and their very nature is frequently obscure. But there is no doubting the significance of the ancient finger-posts which, half buried in the mists of antiquity or erased by the busy fingers of time, still point the pathway along which man's race has fought and won its way to the supremacy of the animal hosts.

It is in the study of the early phases of human development that the most significant clues to man's past history are to be found. Biological science in this respect but repeats the scientific methods of common history; and the genesis of human motives, ethical and political, is most truly construed when the knowledge of their growth and development is within the historian's grasp. A marked similarity of development, then, is firstly found to characterise the earliest phases of development throughout the vertebrate series. Human existence steps forth upon the stage of time, potentially endowed with the cumulative powers of its ancestry no doubt, but likewise exhibiting a lowliness of actual garb and substance which places our beginning at the veritable root stock of the tree of life. The earliest germ of the human frame is a structureless mass of protoplasm, attaining a diameter of the one-hundred-and-twentieth part of an inch,

and being in this guise practically undistinguishable from the germ which is to develop into that of any other vertebrate form. Whatever this germ or "ovum" may become, it presents in substance, chemical composition, and microscopic characters, no features which are other than those seen with equal distinctness in that of every fish, frog, reptile, bird, or quadruped. Humanity thus, as a matter of bare, unadorned fact, starts from a structural platform which is common to all the members of the great "backboned" group. The primitive changes which occur in the history of this germ are next noted to run in strictly parallel lines with those viewed in the development not merely of all other vertebrates, but it may be added of all other animals from the Sponges to the "backboned" series. The changes in question are collectively termed the "segmentation" of the germ. By this term is meant the division of the protoplasm of the "germ"—which in itself is one "cell"—into a large number of similar and smaller cells. This result has been very aptly compared to the process of fashioning many similar bricks from the common clay of a field. The primitive "germ" is such a field in miniature, and the cells which result from its division are the units, through the subsequent arrangement of which, the animal house in general, and the human edifice in particular, are respectively built. There is no reason to doubt that what has been seen to occur in the course of the frog's development, and what is known to occur in the fashioning of the developing rabbit—a member of man's own class—likewise occurs in the outlining of the human form. As the course of development therefore proceeds, we discover that the cells arising from the division of the primitive germ arrange themselves to form a rounded, and in lower forms cup-shaped body, whose wall is double, and which has been named the *gastrula*. Here ensues an important observation in so far as the genesis of animal forms is concerned. It is known that in the developmental history of every class of animals, from the Sponges to the "backboned" series, this cup-stage or "gastrula" is represented. Hence, biological opinion, regarding this universally occurring landmark in animal history, assigns to it a high rank in the list of the guides which point out the paths of our development and evolution in the past. We know of certain animals among the Sponges and Zoophytes, which, never advancing beyond this cup-stage, appear before us as permanent "gastrulas." That which is a transitory stage in our own early history becomes, when arrested, a permanent and adult stage of lower life. If, therefore, the story told us by our development is to be construed at all, it must be held as showing that "once upon a time" our most primitive ancestry began under the guise of a protoplasm-speck represented to-day by the germ which forms the initial stage in our history. Whilst the recital also clearly shows us that the first rise in

life with which this remote ancestral stock was favoured, occurred when the structureless animal of the first period became the "gastrula-cup" of the second. It is in this fashion that we are led to see in the development of man or of any other animal form, a panorama of the evolution of its race. We can thus also conceive how meaningless on any other supposition in the eyes of naturalists, are all those interesting stages which herald the genesis and production of each individual animal or plant that is born into the world.

An interesting episode in the history of human genesis and of vertebrate development at large, consists in the further observation that at an early period after the "gastrula stage," and, indeed, even contemporaneously with the appearance of that stage itself, the cells of the primitive body arrange themselves in two layers, an outer and inner, whilst a third layer is in due time formed between them. From these three layers, and by their subsequent elaboration to form the fundamental body-substance, all the organs and parts of animals are formed. The outer layer is named the *epiblast*. From this tissue are formed the outer or "scarf-skin," and the brain and spinal cord. It is exceedingly curious to note that the most superficial layer of our bodies, and the deeper nervous centres, are formed from one and the same layer. The inner layer is known as the *hypoblast*; and from it are elaborated the lining membrane of the digestive canal and that of the lungs. The middle layer receives the name of the *mesoblast*. This latter structure may be credited with forming the great bulk of the body. To it the bones, muscles, bloodvessels, and viscera generally, owe their origin. Tracing back our progress in the matter of individual formation, we thus arrive at the conclusions that, to begin with, our bodies, however complex they may appear, sprang each from a single cell, that this cell begets many others, and that these cells, finally arranging themselves in three layers, form the entire frame. And these facts, it may be noted, apply with equal force to the genesis of a worm or a snail, and to the fashioning of the human frame.

Later on, the progress of human development is found to exhibit certain features which, equally with the foregoing stages, testify to the far back ancestry to which humanity owes its being. A survey of one or two features of special interest in the development of lower Vertebrates will preface in a natural manner the brief study of the peculiarities of lower life in which man is found to share. When the development of the fish is studied, we observe that at an early stage in his history certain clefts appear in the sides of the neck, these clefts being separated from each other by solid bars or partitions. The clefts are known as the "branchial clefts" or "gill clefts," and the bars as the "branchial" or "gill arches." From four to six pairs of these clefts exist in the fish, and as fishes breathe by means of gills

the development of the structures just described, must be regarded as an occurrence of the most natural description. In such animals also as the frogs, which breathe by gills in early life, or those curious efts, the Proteus and its neighbours, which breathe by gills throughout life and develop lungs in addition, the appearance of gill clefts and arches in their early existence must be regarded as a perfectly normal and natural feature. Here, however, the apparently regular course of gill development ends. For, when we ascend to the three highest classes of vertebrate animals—reptiles, birds, and mammals —we discover that lungs, and lungs alone, form the breathing organs of these groups; gills having no share whatever in their respiration. Yet the puzzle of life waxes apparently intricate enough in its details, when we discover that in the early life of each reptile, bird, quadruped, and man, the gill clefts appear with as unfailing regularity as in the gill-breathing fish or frog. Whatever may be their ultimate fate, it is, at least, certain, that the gill clefts and arches of humanity are a veritable possession of our early life. Their further history is simply one of obliteration, united with a degree of modification in which they become elaborated into structures useful to higher life, but unknown, of course, in the lower tribes which retain their gill arches as supports for their gills. We find that the first of these gill clefts becomes converted into part of the ear structures. The outer canal of the ear, the "drum," and the Eustachian tube which places ear and throat in communication, represent the modified first gill cleft of our early life. As has been remarked, it is a curious fact of human development that the foregoing parts in the ear of man represent the last survivals of the gill-opening of a fish-like ancestry. The "arches" which separate the "clefts" are likewise elaborated in human development. The bone (*hyoid*) which supports the tongue, and the small bones of the internal ear, are the ultimate representatives of the gill arches of our early life.

Thus we may read, with more than common interest, the story of the genesis of our race, which is written in the progress of our early development, and which should possess for humanity an attraction far exceeding that contained in any other recital connected with the history of our species. If the facts of our development and of our bodily structure are to be interpreted in a rational sense, the inferences which we may draw from the recital are by no means of doubtful nature. For they tell us at once of descent and ascent—of a long ancestry, and of a rise and progress from lower life to the rank and title which humanity legitimately claims as sovereign of the animal kingdom. Such a study not only clearly shows us the perfection to which, as a species, we have attained, but likewise accounts, in the conclusion it formulates respecting our genesis, for the imperfections and rudiments of lower life which, like the re-

echoes of the past, still dwell with us, and remind us of the length of our pedigree. Nor do such studies remind us only of the antiquity of our origin. They recall to mind with equal force the nobility with which such an ancestry invests our race, because they show us that we are the highest products of laws of development which invest and rule the whole of the animated universe. To stand at the head of a creation of such surprising and almost incomprehensible extent, and which has been fashioned by laws and powers of such exceeding complexity, must surely confer a patent of nobility upon our race, compared with which all the prepossessions of the past appear of sordid order. There is the ring of truest wisdom in the words with which Mr. Leslie Stephen closes his reflections regarding the effect of the newer ideas of human origin on the moral progress of the race. "If Darwinism demonstrates that men have been evolved out of brutes," says Mr. Stephen, "the religion which it takes into account will also have to help men to bear in mind that they are now different from brutes."

II.

SOME ECONOMICS OF NATURE.

AMONG the views of living Nature, and indeed of the inorganic universe as well, which receive tacit acceptance and sanction from ordinary thinkers, there are certain phases deemed incontrovertible in their plain, every-day demonstration. Before our eyes, for instance, we see *Madre Natura* spending her wherewithal in apparent thriftlessness and woeful waste. The proverb, "Waste not, want not," so thoroughly and repeatedly dinned into youthful ears, would seem to have no application to the works and ways of the prodigal All-mother that surrounds and encompasses us. The flower that "blooms unseen and wastes its sweetness on the desert air," is a very mild illustration of a nature-spirit which appeals in more forcible ways to the mind as an example of needless contrivance, wasted effort, and useless prodigality. We fly to Tennyson for that apt quotation concerning the fifty seeds produced, and whereof only one comes to the full fruition of its race. Every summer day shows us how true apparently the poetic axiom holds. Every spring-time seems to teach us the same truism. The pines and other cone-bearing trees discharge their pollen or fertilising matter in clouds. The winds, as Nature intends, sweep this pollen from their branches, on the "flowers" of which it has been produced. Carried through the air for miles, so much of the pollen-cloud will fall on the receptive "cones," fertilise the ovules, and thus convert them into seeds, whence a new dynasty of trees may arise. But countless showers of pollen are spent in vain, irrecoverably lost, and sent abroad to no purpose whatever. They fall on barren ground; they litter the earth miles away from their parent trees, or cover the surface of lakes for miles with a yellow film—their purpose futile and their production vain. True it is, as the botanist will tell us, that more pollen must be produced in the case of wind-fertilised plants than is found in that of insect-impregnated flowers. It is a case of "hit or miss" with the wind-fertilised trees, while it is an illustration of an exact calculated aim with the flowers. Hence Nature has to provide for the contingency which awaits her efforts in the former instance by providing a very copious supply of pollen. She is in the position here, not of the marksman who takes deliberate aim at the bull's-eye with his rifle and single bullet. Contrariwise, she uses her Gatling gun or her mitrailleuse in the act of fertilising the trees. She showers her bullets at the object in the hope that

some of them will hit, and with the equally plain expectation that many must miss altogether. The whole process appears to be wasteful in the extreme—natural affairs notwithstanding; and the Tennysonian couplet is practically realised when the spectacle of tons of wasted pollen is beheld, discharged as these are at the mercy of any wind that blows, and sent into the air to accomplish at haphazard what in other plants is often effected by deliberate and carefully calculated mechanism.

The notion that Nature possesses any system of economics at all might well be questioned by the observer who discerns the apparent waste through which many natural works and ways are carried out. But here, as in the case of so many other phases of life, the two sides of the medal must be carefully studied. It is not the case that Nature is uniformly neglectful of her resources, any more than it is correct to say that she is always saving or perennially economical. Circumstances alter cases in the phases of natural things as in human affairs, and we may readily enough discover that in several instances a very high degree of well-calculated prudence and foresight, speaking in ordinary terms, is exercised in the regulation of the universe of living and non-living things alike.

Take as a broad example of the close adjustment of ways and means to appointed ends the relationship between animals and green plants in the matter of their gaseous food. That the animal form demands for its due sustenance a supply of oxygen gas is, of course, a primary fact of elementary science. Without oxygen, animal life comes to an end. This gas is a necessary part of the animal dietary. It supplies the tinder which kindles life's fuel into a vital blaze, and in other ways it assists not only the building-up but the physiological "breakdown" of the animal frame. Part of this "breakdown" or natural waste accompanying all work, like the inevitable shadow, consists of carbonic acid gas. This latter compound is made up of so much carbon and so much oxygen. It arises from the union of these two elements within the body, and is a result of the production of heat, representing, in this way, part of the ashes of the bodily fire. Viewed as an excretion, as a something to be got rid of, and as a deadly enough element in the animal domain, this carbonic acid is a thorough enemy of animal life. It is not only useless in, but hurtful to the animal processes. Ventilation is intended as a practical warfare against the carbonic acid we have exhaled from lungs and skin; and "the breath, rebreathed," is known to be a source of danger and disease to the animal populations of our globe. Here, however, the system of natural economics appears to step in and to solve in an adequate fashion this question of carbonic acid and its uses. Just as the chemist elaborates his coal-tar colours from the refuse and formerly despised waste products of the gasworks,

so Dame Nature contrives a use for the waste carbonic acid of the animal world. She introduces the green plants on the scene as her helpmates and allies in the economical work. Every green leaf we see, is essentially a devourer of carbonic acid gas from the atmosphere. That which the animal gives out, the green plant takes in. Not so your mushrooms and other grovellers of the vegetable kingdom, which, having no green about them, refuse to accept the cast-off products of the animal series, and despise the carbonic acid as a poor but proud relation discards the gift of our old garments. The green plant is the recipient of the animal waste. The leaves drink in the carbonic acid which has been exhaled into the atmosphere by the tribes of animals. They receive it into their microscopic cells, each of which, with its living protoplasm and its *chlorophyll* or green granules, is really a little chemical laboratory devoted to the utilisation of waste products. Therein, the carbonic acid gas is received; therein, it is dexterously split up, "decomposed," as chemists would have it, into its original elements, carbon and oxygen; and therein is the carbon retained as part of the food of the plant, while the oxygen, liberated from its carbon bonds, is allowed to escape back into the atmosphere to become once again useful for the purposes of animal life.

There would thus appear to be a continual interchange taking place between the animal and plant worlds—a perpetual utilisation by the latter of the waste products of the former. It is immaterial to this main point in natural economics that the reception of carbonic acid by green plants can only proceed in the presence of light. It is equally immaterial that by night these green plants become like animals, and receive oxygen (an action which, by the way, they also exhibit by day) and emit carbonic acid. These facts do not affect the main point at issue, which is the direct use by the plant of animal waste, and a very pretty cycle of operations would thus appear to have been established when botanical research showed the interactions to which we have just alluded.

Going a step further in the same direction, we may find that this utilisation of animal waste is by no means limited to the mere reception and decomposition of carbonic acid gas by green plants. It may be shown that the economical routine of Nature is illustrated in other phases of the common life of the world. The general food of plants is really animal waste. We fructify our fields and gardens with the excretions of the animal world. The ammonia which plants demand for food is supplied by the decay of living material, largely animal in its nature; and even the sordid fungi flourish amid decay, and use up in the system of natural economy many products for which it would be hard or impossible to find any other use. What we, in ordinary language, term "putrefaction" or "decay," is really a

process of extermination of the decomposing matter. No sooner does an organism—animal or plant—part with vitality and become as the "senseless clod," than thousands of minute organisms—the "germs" of popular science—make it their habitation and their home. The process of putrefaction, unsavoury as it may be, is really Nature's way of picking the once living body to pieces, of disposing it in the most economical way. So much of it is converted into gas, which, mingling with the air, feeds the green plants as we have noted. So much of the dead frame is slowly rendered into nothingness by the attack of the microscopic plants which are the causes of decomposition. Nature says to these lower organisms, "There is your food. In nourishing yourselves, accomplish my further work of ridding the earth of yon dead material." And so much, lastly, of the once living frame—assuming it to have been that of the higher animal—as is of mineral nature, and therefore resists mere decay, will in due time be dissolved away by the rains and moisture, and be carried into the soil, to enter into new and varied combinations in the shape of minerals which go to feed plants. Shakespeare must surely have possessed some inkling of such a round of natural economics when we find him saying—

> Imperial Cæsar, dead and turn'd to clay,
> May stop a hole to keep the wind away.
> Oh! that that earth which kept the world in awe,
> Should patch a wall t' expel the winter's flaw.

Continuing the study, we may see yet further glimpses of the great system of general regulation which guards Nature from overdrawing her accounts in connection with the arrangement of living things. Not only in beings of high degree, but in animals of low estate, do we meet with illustrations of the economy of power and the saving of needless expenditure of force and energy which Dame Nature practises. The study of human anatomy, which of course is one in many points with the comparative science as applied to lower life, reveals not a few instructive examples of this saving tendency in life's ways. The human head, for example, is nicely balanced on the spine. Compared with heads of lower type, this equipoise forms a prominent feature of man's estate. The head-mass of dog, horse, or elephant requires to be tied on, as it were, to the spine. Ligaments and muscular arrangements of complex nature perform their part in securing that the front extremity of these forms should be safely adjusted. But in man there is an absence of effort apparent in Nature's ways of securing the desired end. The erect posture, too, is adjusted and arranged for on principles of neat economy. The type of body is the same as in lower life. Humanity appears before us as a modification, an evolution, but in no sense a new creation. Man rises from his "forelegs"—arms being identical, be

it remarked, with the anterior pair of limbs in lower life—and speedily there ensues an adaptation of means to ends, and all in the direction of the economical conversion of the lower to the higher type of being. The head becomes balanced, and not secured, as we have seen, and thus a saving of muscular power is entailed. Adjustments of bones and joints take place, and the muscles of one aspect, say the front, of the body, counterbalance the action of those of the other aspect, the back; and between the two diverging tendencies the erect position is maintained practically without effort. So, also, in the petty details of the work Nature has not been unmindful of her "saving clause." We see this latter fact illustrated in the disposition of the arrangements of foot and heel. One may legitimately announce that man owes much to his head; but the truth is he owes a great deal of his mental comfort and high physical economy to his heels. The heel-bone has become especially prominent in man when compared with lower forms of quadruped life. It projects far behind the mass of foot and leg, and thus forms a stable fulcrum or support, whereon the body may rest. Here, again, economy of ways and means is illustrated. There is no needless strain or active muscular work involved in the maintenance of the erect posture in man. It is largely a matter of equipoise, wrought out through a scheme of adaptation which takes saving of power and energy as its central idea.

Physiological research lays bare many other points in human and allied life which bear out the contention and principle that natural economics is a powerful and prevailing reality of life. Muscles are ordered, for example, on the plain principle of single acts and of divided tasks. Thus a man bends his forearm on the upper arm largely by aid of the familiar "biceps." This done, the "biceps" retires from the field of work. The arm is straightened by the action of a different muscle, the "triceps." So, also, with the shutting and opening of the hand. While the "flexors" of the fingers placed on the front palm or surface of the limb close the hand, it is the "extensors" of the opposite aspect of the forearm (whose sinews we see in the back of the hand) which open or extend our digits. There may be multiplication of organs here, it is true; but, given the original power to produce them, there is a clear economy of vital wear and tear exercised in the avoidance of too onerous tasks being laid upon any one muscle.

It is something of this principle which we find reflected also in the circulation of the blood. Here we see the heart's left ventricle (or larger cavity of the left side) driving blood, as does a force-pump, out into the great system of arteries, which everywhere throughout the body carry the nutrient stream. No sooner, however, has the blood-stream, impelled by the contraction of the muscular walls of the heart's ventricle, passed into the great main artery (the aorta)

which arises from the heart, than an economical principle of an important kind comes into play. This principle is represented by the elasticity of the arteries which bear the blood to the body. They possess a circular coating of muscle which diminishes in thickness as the vessels grow smaller and smaller, and are therefore removed from the influence of the pumping-engine of the circulation. The arterial coating is itself elastic, and the whole system of these vessels is thus endowed with a high amount of resiliency. Their internal coats are smooth and shining, as also is the lining of the heart's cavities; friction being thus reduced to its minimum. The united sectional area of the branches of the dividing artery is larger than the same area of its stem, so that the collective capacity of the vessels increases markedly as we pass from the heart outwards to the minuter channels of the circulation.

The blood is thus driven through an elastic set of tubes presenting the least possible resistance to the flow of fluid through them, and economy of power is thus again witnessed in the details of the human estate. Nor is this all. That there exists resistance to the flow of blood is, of course, a necessary condition in any system wherein large tubes or arteries branch out into small tubes (the capillaries), and these, again, unite to form larger or return vessels—the veins. The problem of living Nature would here appear to resolve itself into the inquiry, how the apparently intermittent, or spasmodic, work of the heart may be converted into a constant and continuous action.

If we suppose that a pump drives water through a rigid pipe, we see, in such a case, just as much fluid to issue from the pipe's end as entered it at the stroke of the pump. Practically, also, the escape of the water from the pipe takes place almost simultaneously with its entrance therein. If we place some obstacle or resistance to the free flow through the pipe, while the pump acts as before, the quantity of water expelled will be less, because less fluid enters the pipe. Just as much water will leave the tube as enters it under the two conditions of no resistance and of the presence of such obstacle to the flow. If now we substitute for our rigid pipe an elastic one, the resistance to the water-flow is diminished no doubt, but the fluid will, as before, issue in jets; that is, in an intermittent and not continuous fashion. There is "easy come and easy go" in the elastic tube, as in the rigid one where no resistance exists. The elasticity, in other words, is not called upon to act in modifying the flow because the course of the fluid is clear and open. Suppose now, that some obstacle or resistance is introduced into the elastic tube. The fluid cannot escape as readily as before, and it tends, as a matter of course, to accumulate on the near or pump side of the obstacle. The tube gives, so to speak, and accommodates the water which is

forced to wait its turn for exit. Each stroke of the pump, it is true, sends its quantity into the tube, but between the strokes, the swollen and expanded tubes in virtue of their elasticity, act as an aid to the pump, and by exercising their power, force the accumulated fluid past the point of resistance. There is rest in the rigid tube between the pump-strokes. There is, contrariwise, activity in the elastic tube, due to the overcoming by its elasticity of the obstacle to the flow, and to its work of keeping the fluid moving and of avoiding distension and blockage. It is possible, moreover, to conceive of the elastic reaction of the tube being so great that the accumulated fluid will be made to pass the knotty point before the next stroke of the pump occurs. Let us imagine, lastly, that the strokes succeed one another in rapid succession, and that the elasticity of the tube is powerful enough to overcome the resistance opposing the flow of fluid, and we shall arrive at a state of matters wherein not only will the obstacle become practically non-existent while as much fluid leaves the tube as enters it, but the flow from the far end of the tube will also be converted into a continuous and stable stream.

This latter condition of matters is exactly reproduced in the circulation of the blood. There is great resistance found on the arterial side of the heart. Each impulse has to send blood into a vessel which is elastic in itself, as we have seen; but immediately on the first stroke of the heart succeeds a second. Hence the blood accumulates on the heart's side before that propelled by the first stroke has been completely disposed of. Distension and strain of the vessel succeed, and one of two results must follow. Either the circulating arrangements must collapse, or the elasticity of the tubes into which the blood is being perpetually forced, will acquire power sufficient to overcome the resistance, and to propel onwards the amount of blood with which each stroke of the heart charges the circulation. Here the true meaning of the rapid work of the heart and of the elasticity of the arteries becomes apparent. The otherwise intermittent flow of blood is converted into a continuous stream. The heart keeps the arteries over-distended on the near side of the resistance; while these elastic tubes, so treated, discharge themselves in turn onwards, and at a rate which corresponds to that with which the force-pump action of the heart charges them from behind. And so, tracing the hydraulics of the circulation through its phases, we see, firstly, the heart over-distending the elastic arteries. We witness the arteries emptying themselves into their minute continuations, the capillaries, and through these latter into the veins or return vessels. The economy is witnessed here in the easy means adapted for converting without complications a spasmodic flow of blood into a continuous stream; insuring also that the amount of blood which flows from the arteries to the veins during the heart's stroke and pause

exactly equals that which enters the circulation at each contraction of the ventricle. In other words, the tremendously high pressure of the arteries of our bodies, saves at once the multiplication of bodily pumping-engines, and conserves the force of the heart itself.

There are other points connected with the circulation, more or less intimately, to which a passing allusion may be made. The low-pressure flow of blood in the veins upwards to the heart from the lower parts of the body is thus favoured by the high pressure of the arterial system, and natural economy of energy is thus again exemplified. The arteries seem to be intent on the work of getting rid of their contents through the capillaries into the veins. There is no resistance, in fact, to the venous flow which is carried on at low pressure. Again, the ordinary muscular movements of the body are utilised in the economy of life, to favour the return of the venous blood. For the veins are compressed in the muscular movements, and, as they are provided with valves which prevent back-flow, the compression can act in one way only—namely, to aid the upward or backward return of blood to the heart's right side.

The overplus of the blood is known as *lymph*, and is gathered from the tissues by vessels known as *absorbents* or *lymphatics*. These return the lymph to the blood-current for future use. Nature "gathers up the fragments" here as elsewhere, and sees that the lymph or excess of the blood supply is once more garnered into the vital stream of the circulation. If we ask how this lymph-flow is maintained from all parts of the body towards the great vein in the neck where the lymph joins the blood, we again light upon the question of high pressure in one side of matters and low pressure in the other side. All the ordinary movements of our bodies are economically pressed by Nature into the service of the lymph-flow. As in the veins, the valves of the lymphatics prevent backward movement, and as in the veins the muscles compress the vessels, and common movement thus assists a special end. Even the motions of breathing favour the return of the lymph. For when we inspire, the pressure in the great veins becomes negative in character, and lymph is thus capable of being sucked into the circulation from the main tube or duct of the lymph-system. When we "breathe out" the pressure in the large veins increases it is true, but a valve guards the entrance, which in inspiration is free, and untoward consequences are thus prevented. It is a notable fact that in many animals organs known as lymph-hearts are developed. As in the frog, these contractile organs assist the lymph in its return to the circulation. It therefore becomes of interest to note how in the higher walks of existence, the mechanical contrivances and actions of the body undergo an evolution which not only avoids multiplication of parts and organs,

but also conserves and economises the energy which has to be expended in the maintenance of life.

The function of breathing has been incidentally alluded to in the course of the foregoing remarks, and, in considering the details of this paramount duty of life, we find additional proof of the fact that Nature's economics in higher life are frequently expressed in terms of admirable mechanical contrivance. Primarily, in the case of respiration, we find the bony elements of the chest fitly developed in view of certain physical qualities, of which elasticity forms perhaps the chief. The front wall of the chest is practically composed of cartilage or "gristle." The "costal cartilages," or those of the ribs, intervene between the upper seven ribs and the "sternum" or breast-bone. The eighth, ninth, and tenth pairs of ribs also possess cartilages, but these run into and join the gristly extremity of the seventh pair; while the last two pairs of ribs (eleventh and twelfth) spring from the spine behind, but are not attached in front at all. Essentially, the chest is a bony cage, possessed of high elasticity. Even in the dried skeleton, pressure from above, downwards or backwards, applied to the front of the chest shows this quality of its structures in a marked fashion.

If we study, even superficially, the mechanism involved in breathing, we may gain an idea of the keynote of the process in so far as economy of force is concerned. "Breathing in," if we reflect upon the nature of the act in our individual persons, is a matter of some trouble. It involves a large amount of labour; it gives us much muscular trouble, so to speak. In the case of a deep inspiration, we exaggerate the effort seen in normal breathing, and we may therefore appreciate still more exactly the expenditure of energy required to carry on this necessary function of vitality. But "breathing out" is a widely different matter. We let the chest "go," as it were, at the close of inspiration, and, without an effort, it returns to its position of rest. We expend force in "breathing in"; we appear to exert none in "breathing out." The former is a muscular act performed by a complex series of muscles, and participated in by the lungs and other structures connected with the chest. The latter is an act which partakes, even to the common understanding, of the nature of a recoil; and in this latter supposition we perceive how economy of labour in the human domain is again subserved.

Breathing, then, means that we enlarge the chest by the action of certain muscles, that the pressure of air in the lungs becomes reduced as compared with that outside, and that in consequence air rushes into the lungs through the windpipe until an equality of air-pressure inside and outside the lungs is produced. This is the act which is accomplished forcibly, against gravity, and by aid of very considerable muscular power. We are said to perform no less than twenty-

one foot tons of work by means of our respiratory muscles in twenty-four hours—that is to say, the work of these muscles, extending over twenty-four hours' period, if gathered into one huge lift, would raise twenty-one tons weight one foot high.

By a little additional muscular labour we take in a deep breath, still further enlarge the chest, and inhale an additional quantity of air. The great muscle named the diaphragm or "midriff," which forms the floor of the chest, is the chief agent involved in the act of inspiration. It descends while the ribs are elevated, and as the chest enlarges, the inflow of air takes place. The lungs themselves are highly elastic bodies. They follow the movements of the chest walls, and thus expand and contract—they suffer dilatation and compression—as the chest walls move in the acts of respiration. But, when ordinary "breathing out" is studied, we see that it is as clearly a matter of recoil, as has been stated, as "breathing in" is a matter of exertion. Here elastic reaction steps in to complete the full act of breathing. Nature saves her energies and husbands her strength in this truly physiological division of labour. When we inspire, the lung-substance, elastic in itself, is put on the stretch; the cartilages of ribs and breast-bone are similarly elevated and expanded, and the whole chest is, so to speak, forced into its position of unrest. Then comes the reaction. The muscles of inspiration cease their action; they relax, and the elastic lungs recover themselves and aid in forcing out the air they contain. So, also, when the rib-muscles have come to the end of their tether in elevating these bones, the elastic recoil of the ribs and breast-bone serves to diminish the capacity of the chest, and to further expel the air from within its contained lungs. Laboured or excessive breathing, as most readers know, calls into play extra help from muscles not ordinarily used in natural respiration. This fact takes us out of the normal way of life into the consideration of abnormal or diseased states, and demonstrates that the economy of Nature disappears when phases of morbid action fail to be subserved. In natural breathing, however, we see conservation once more in the easy recoil which follows the muscular labour of inspiration. The physiology of a sigh and its relief can be readily appreciated on the basis which shows how the easy act of expiration is correlated with the more laboured action and duty of enlarging the chest.

A phase of Nature which is by no means foreign to the foregoing illustration of the conservation of power in the human body is presented to us in several aspects of lower life. In the breathing of certain animal forms, belonging to the *Molluscan* races, we may discover equally admirable examples of economy in natural work. Among the Cephalopods or cuttlefishes we observe such features. Any one who has seen an octopus resting in its tank in an aquarium,

must have been struck by the puffing and blowing movements of the sack-like body, the nature of which excited Victor Hugo's imaginative powers in the "Toilers of the Sea." The octopus is seen to inspire and expire with great regularity. The soft body expands and contracts rhythmically enough to excite a natural comparison between its respiratory acts and our own. If we could dye the water so that our eye could follow the currents which the octopus inhales and exhales, we should perceive that at each inspiration the soft body expands, and water is drawn in two currents into the neck-openings. These openings lead directly each, into a gill-chamber of the animal. Here, enclosed in its own cavity, we find a plume-like gill. In its nature, this structure is simply a mesh-work of blood-vessels, and thus comes to resemble a lung in its essential features. Impure blood—that is, blood laden with the waste materials of the octopus-body, with the products of the vital wear and tear—is driven into the gill on one side. Subjected to the action of the oxygen gas contained in the water breathed in, the blood is purified. Its waste materials are given forth to the water, and it is passed onwards out of the gill on its way to the heart for recirculation throughout the cuttlefish-frame.

Breathing in oxygen entangled in the water is, therefore, in the case of the cuttlefish, an analogous act to that seen in higher animals, which inhale oxygen directly from the air. The octopus, however, performs an expiratory act likewise. Placed below the head is a short tube, named in zoological parlance the "funnel." When cuttlefish inspiration has come to an end, expiration begins. The body contracts, and the water, which a moment before was drawn into the gill-chambers by the neck-openings, is expelled from the "funnel." The openings of entrance are guarded by valves. These close when expiration begins, and the water has no choice save to find a forcible exit by the tube just named. So far, in octopus existence, it would seem as though there was no economy of power exhibited in the act of breathing. Muscular action expands the soft body, and muscular force contracts it. There is exhibited here a plain difference between the octopus and the higher vertebrate.

But the story of cuttlefish-economy is not yet completed. A moment more and your octopus, which sat crouched in the bottom of the tank, is seen to wing its way through the water. It skims like a living rocket through the clear medium in which it lives, as if impelled by some marvellous and invisible agency. The secret of this flight is the solution of cuttlefish-economy and reserve force. So long as the resting mood prevails, the water used in breathing is ejected slowly, or at least without any marked display of force. But when locomotion has to be subserved, and when the cuttlefish desires to swim, it propels itself through the water by aid of a

veritable hydraulic engine. The effete water from the gills is ejected with force from the funnel, and by the reaction of this *jet d'eau* upon the surrounding medium, the animal is enabled to execute its aquatic flights. Economy of a very rigid order is illustrated clearly enough in octopod existence. The otherwise useless "breath" of the animal becomes converted into a means of locomotion.

A still closer parallel to the human chest-recoil, perchance, may be found in the case of certain poor relations of the octopus. These lower forms are the mussels, oysters, cockles, clams, and other bivalve shell-fish which frequent our own and other coasts of the world. Encased in its shell, a mussel or oyster, all headless as it is, and possessing in its way a strictly "local habitation," in that it is a fixture of the coast or sea-depth, presents us with the type of an apparently vegetative life. But there is abundant activity illustrated within the mussel or oyster-shell. There are millions of minute living threads—the *cilia* of the naturalist—perpetually waving to and fro as they crowd the surface of the gills. These cilia, acting like so many microscopic brooms, draw in the currents of water necessary for food and breathing, while the same incessant movement which draws in the fresh water circulates it over the gills, and in turn sweeps it out as waste material from the shell. The oyster implanted in its bed, or the mussel attached by its "byssus" or "beard" to the rock, exhibits a half-open condition of the shell as its normal state. The animal lives—as may be seen on looking at a tub of oysters as they lie amid their native element—with the shell unclosed for purposes of nutrition and breathing. If, however, we tap the living oyster or mussel ever so lightly, we find the shell to close with a snap that renders the persuasion of the oyster-knife necessary for its forcible unclosure. In such a case the animal's senses, warned of possible danger by the tap on the shell, communicate to its muscular system a nervous command, resulting in a movement which, as regards the oyster, reminds one of nothing so forcibly as the cry and action of "shutters up" in a Scotch university town when snowballing begins.

The muscular system of these shell-fish is disposed in simple fashion. Look at the inside of an oyster-shell, and note the thumb-like impression you see occupying a nearly central position. This is the mark of the "adductor" muscle of the oyster, or that which draws the shells together. The secret of successful oyster-opening is simply the knowledge, acquired by much practice, of hitting the exact position of the "adductor" muscle, and of dividing its fibres with the knife. The enormous power of this muscle to keep the valves in apposition can be appreciated most readily, perhaps, by the amateur "opener" of these bivalves. In the mussel there are two such "adductors," one at either extremity of the shell, and we note

the impressions which these structures leave on the shell's interior. The latter animal has thus a double holdfast, whereas the oyster has but a single one. If the function of these structures is thus concerned with the *clôture* aspect of bivalve life, how, it may be asked, is the opening of the shell provided for? This is exactly the point to which Nature directs her energies in arranging her economical disposition of the oyster or mussel constitution. We have seen that the natural and persistent state of oyster life is a condition of unclosure, while the opposite action of shutting the shell is only a transitory and infrequent phase of bivalve existence at the best. There is afforded a chance for the exercise of mechanical expediency in making the open state of the shell a matter of ease and one carried out without effort or exercise of energy. And so is it contrived.

Suppose that, placing two oyster-shells in their natural position, we insert a piece of india-rubber between the valves at the point where they are hinged together. If we now forcibly close the shells by pressure, the india-rubber is compressed. When we release the pressure of our fingers, the elasticity and recoil of the india-rubber forces the valves apart. In such a fashion, then, does Nature provide for the constant maintenance of the unclosed condition. The "ligaments" of the shell are natural elastic pads existing at the hinge-line. By their elasticity they keep the valves unclosed. There is no strain involved in the action, which is a merely mechanical one after all. But when the more infrequent act of closure has to be performed, then muscular energy requires to be displayed. The quick snap of the valves reminds us that muscular exertion, even if necessitating vital wear and tear, has its corresponding advantage in the rapidity and effectiveness with which it provides for protection against the entrance of disagreeable or noxious elements into the internal arrangements of oyster or mussel life. There is illustrated here, a clear saving of life-force and a persistent system of vital economics in the substitution of a mechanical for a muscular strain where the maintenance of the open state of the shell is concerned.

Returning to the human domain for a final glance at our subject, there are found in the spheres of digestive nervous actions many facts and examples proving the exercise of a constant economic surveillance of our life. The digestive duty may be defined as that whereby our food is converted into a fluid capable, when added to the blood, of repairing and replenishing that fluid. To this end, as is well known, the nutriment has to pass along the tube known as the digestive system, and to be subjected to the chemical action of the various fluids or secretions which are poured upon it in the course of its transit. In the stomach, for example, certain important food-principles—those of nitrogenous kind—are first selected as it were from the nutriment, chemically altered by the gastric juice, and ren-

dered capable of being absorbed into the system. Instead of waiting for a lengthened period for the arrival of this important part of its commissariat, the body receives such food-elements soon after digestion begins. The fats, starches, and sugars are, on the contrary, passed onwards to be digested in the intestine. They become available for nutrition only after several hours of digestive work. The principle of "small profits and quick returns"—itself an economical and commercially satisfactory mode of doing business—is illustrated in the digestive transactions of the body. That which is urgently required for the frame is quickly supplied, while the, in one sense, less important foods are left for later absorption.

In this economical work the liver plays an important part. Long ago in physiological history that organ was regarded simply as a bile-making machine. The bile, thrown upon the food just after it leaves the stomach, was regarded as an all-important digestive fluid. To-day we have entered upon entirely new ideas of the liver's work. As Dr. Brunton has aptly put it, the liver is no more to be regarded as a mere bile-maker than the sole use of an Atlantic liner is to be found in the manufacture and display of the water-jets which issue from the sides of the ship as the waste products of her engine-work. The liver is really a physiological constable placed at the entrance of the blood circulation. Into it are swept digested matters. These are further elaborated and changed so as perfectly to fit them for entrance into the blood. When the functions of the liver are suppressed or rendered inactive, elements of deleterious kind are apparently allowed to enter the circulation, and thus produce all the symptoms of the body poisoning itself. This being so, we begin to see that the bile is really a mere by-result of the liver's work, as the condensed water of the steamer is the consequence of the real function of the vessel. Bile is a waste product, and as such it is discharged into the intestine and thus excreted.

But natural economics rule life's actions here as elsewhere. For the apparently useless bile, Nature finds a use. It is discharged upon the food, and mingles with the half-digested nutriment. It has come to exercise a digestive or dissolving action upon fats, a function aptly illustrated by the household use of the "ox-gall" to remove grease stains in the house-cleaning periods of human existence. Moreover, the bile would appear to aid in promoting the muscular contractions of the intestine, and in thus expediting digestive action. It may possess other duties still; but enough has been said to show that the economy which rules living functions is probably nowhere better illustrated than in the utilisation of bile, as a waste-product, in the normal discharge of the digestive act.

Turning, lastly, to the nervous system and its work, we may find exemplified equally manifest phases of economical action. When

we reflect upon the fact that higher life is a tremendously complex matter in its nervous and mental phases alone, we may well be tempted to wonder that we really find time for all the acts involved in the exercise of even our ordinary work. The condition of the brain and nervous apparatus at large might at first sight appear to represent that of an overworked signal-box at an important railway junction. Questions of commissariat, of threatening danger, of demands for information, of difficulties to be cleared away, are perpetually presenting themselves to the nervous apparatus for solution. Yet it is plain that many complex acts, the knowledge of which costs us a deal of trouble to acquire in early life, are not only performed correctly in the absence of all that we may name conscious thought or attention, but are discharged the more efficiently because they are so unthinkingly performed. What we term "automatic" action in human and in lower animal life, is only another name for an economical dispensation of bodily work and of the time that work demands for its performance. Reading and writing do not "come by nature," but require to be taught, and from the "A-B-C" stage of the one, the "pothooks-and-hangers" stage of the other, both demanding thought and care, we work our way slowly upward to a phase when we neither need to think about our "p's" and "q's" in writing or our syllables or sounds in reading. In other words, the intellectual operations of early life have become the "automatic acts" of adult existence. The immense saving of nerve-power—or at least of the highest powers we may collectively name "thought"—involved in such an arrangement may readily be understood. We have not even to waste brain-work in the conduct of our steps in walking. We avoid our neighbours and the lamp-posts without concerning ourselves about either. How large a part of our life is automatically ordered a superficial glance at the history of the nervous system will disclose. The digestion of food, the circulation of the blood, breathing, and many other functions on the due performance and nervous regulation of which the continuity of life depends, are all discharged in this automatic manner.

There is implied herein a large saving of that vital wear and tear of which we have already spoken. Life would indeed be far too short for the safe and satisfactory discharge of the duties of even the humblest life—to say nothing of the performance of merely physical duties of existence—had we to "mark, learn, and inwardly digest" every act in our daily round of labour. We may grumble as we please at overwork, and criticise rightly the evil effects of overstrain; but we should also bear in mind that the nature we own has saved us many a worry and many a pang by the exercise of that system of rigid economy which is traceable, in one form or another, in well-nigh every phase of the life universal.

III.

MONKEYS.

THERE is little doubt that our "quadrumanous" neighbours are by no means viewed with favour, or held in high esteem, by the vast majority of mankind. Probably with the exception of interested zoologists, possessed of an inherent weakness for the study of man's nearest allies, or of certain Eastern sects whose veneration of the monkey-race forms an obligatory part of their creeds, the genus *homo* regards his "poor relations" in a zoological sense, with the same disfavour with which, in his most civilised aspect, he looks upon the same relatives in a social sense. Curiosity and disgust are, in fact, the ruling ideas of ordinary mankind, when it surveys the monkey-tribes "from China to Peru" as literally represented in our collections of living animals, or when respectably preserved for national instruction in our museums. Why this should be so, is perhaps more difficult to trace than most of us would imagine. There are more unlikely theories than those which attribute the proverbial hostility of near relatives as the cause of the common repudiation by mankind of the "chattering ape" and "mischievous monkey." Poetry, ever the earliest teacher of mankind, has never viewed the Simian race with favour; and popular culture has been largely content to travel in the poet's wake. Too much the reflex of humanity itself, on the one hand, to be readily accepted as a desirable acquaintance, and too little human—in the best sense of that term—in some of its ways, on the other, to expedite a close alliance with mankind, the ape-type has been ostracised, whilst the rat and mouse have been petted, the hare domesticated, the pig fondled, and even the cruel octopus itself lionised. There exist German legends which picture rats and mice under the guise of human souls. He would have been a bold man, who would have dared to have placed the ape or monkey in the position of the familiar rodents. Myth and tradition, tender to the birds on the whole, and even treating the insects with loving kindness, have been worse than brutal to the nearest allies of man which living Nature knows. Even the Laureate himself, with no prepossessed views of the base in nature, cannot avoid the employment of the "ape" idea as a simile for a something in humanity without which mankind would be both nobler and wiser.

> Move upward, working out the beast,
> And let the ape and tiger die,

is a sentiment entirely in accord with popular ideas. It finds a re-echo in hearts that love Nature wisely and well; but, all the same, it is the echo of a false note, in so far at least as the ape is concerned. Contrast with the poetic declamation against the Quadrumana, Mr. Darwin's recital of the heroic monkey who defended his keeper against the attack of a baboon. "Several years ago," says Mr. Darwin, "a keeper at the Zoological Gardens showed me some deep and scarcely healed wounds on the nape of his own neck, inflicted on him, whilst kneeling on the floor, by a fierce baboon. The little American monkey, who was a warm friend of this keeper, lived in the same large compartment, and was dreadfully afraid of the great baboon. Nevertheless, as soon as he saw his friend in peril, he rushed to the rescue, and by screams and bites so distracted the baboon that the man was able to escape, after, as the surgeon thought, running great risk of his life." Such an account of what the ape-character may exhibit in the way of gratitude and recognition of past kindness, may serve to show that there may be depths of philosophy existent in the Monkey-house at the Zoo' undreamt of in the experience of the humanity that streams through the dwelling-place of the ape tribes.

The terms "monkey" and "ape" are often applied indiscriminately to indicate any member of the great order of mammals which ranks next to man's group in point of structure and function. The name "Quadrumana," applied by naturalists to this group, is also tolerably well known to depend for its application on the fact that monkeys appear to be "four-handed" animals. Scientifically employed, the term "ape" is limited to the highest members of the monkey-order, which, it may be noted, includes within its limits animals of very varied ranks, when their organisation, physical and mental, is taken into account. The name "Quadrumana," given to the group by Cuvier, it may be noted, is by no means correctly descriptive of the monkey-race. They are "four-handed," it is true, in the sense that whilst their hands essentially resemble our own in their grasping powers, their feet are also endowed with hand-like functions. But they are not "quadrumanous," if by that term is implied, what is often popularly believed, that a monkey's lower or hind limbs end each in a veritable hand. At the most, the foot of the monkey becomes hand-like in function through the adaptation of the toes to form a "hand." The essential feature of any hand is, of course, the power of throwing the thumb off the plane of the other fingers, and the adaptation of its muscular arrangements to bring it into opposition to the fingers so that objects of very varied sizes may be grasped between them. Regarded in this aspect, the hand of man is undoubtedly the most perfect instrument of its kind we know. The human thumb can "oppose" the other

fingers either singly or when they are combined; and the perfection of its muscular arrangements assists the digits in the work of grasping large or small objects with precision, and also expedites the performance of the most delicate manipulations which mankind can undertake. Now, the hand of the monkey is constructed on a type essentially similar in all respects to that seen in the hand of man. There are certain monkeys, it is true—the genus *Ateles* or that of the "Spider Monkeys" of the New World, and the African genus *Colobus*—in which the thumb is imperfect and rudimentary; but in ordinary monkeys, the hand is as truly a "hand," of wrist and fingers, as is the "manus" of man. Conversely, the foot of a monkey possesses all the structures which we find in our own pedal extremities. The anatomist finds ankle-bones, instep-bones, and toe-bones in the foot of the ape, exhibiting the closest similarity to those of man. In function alone, is the foot of the ape removed from that of mankind. For in the monkey-tribes, whilst the animals rest upon their feet, these extremities become also utilised for grasping, as we have seen.

That the hand of the monkey is applied to purposes allied to those for which man uses his hands is, of course, a well-known fact. Whoever has watched a monkey, such as the Bonnet Monkey (*Macacus radiatus*), carefully separate the diseased parts of an apple from the eatable parts, or pick out the kernel of a nut from the shell piece by piece, with care and dexterity, must have been struck by the close approximation to the human means of effecting like tasks. Some writers have denied that the hand of the monkey is, in any way, utilised as is that of man. It has been stated that a monkey will not seize a nut with the forefinger and thumb as we do. But from close and long-continued personal observation of such a monkey as the "Bonnet" species, I can certainly affirm that a nut or object of small size is received in quite a natural fashion—judged, that is, by human standard—by forefinger and thumb. The truth is, there are exhibited amongst monkeys, as amongst men, very varied degrees of manual dexterity and intelligence; and it is always unsafe to lay down general rules concerning the habits of one or a few species as if these rules represented exact axioms applying to the class at large. Of the intelligence of the ape-tribe the same remark holds good; and I may add that I have seen enough in my personal study of the monkey-race to convince me that the variations noticeable between the mental traits and powers of different species of monkeys, are as great as any which exist between different races of men, or between ignorant and cultivated individuals of the same race.

With regard to the assumption of the erect posture, it may be said that the familiar and typical human attitude is seldom assumed by monkeys, and then only temporarily, or by the aid of fictitious

supports. There seems little doubt that the habitual attitude of the ape is on "all-fours." A monkey will often raise itself on its hind legs when prompted by curiosity and for the convenience of looking at any object; but the position is a constrained one, and the animal soon returns to its "all-fours," or to its sitting posture. The conformation of the monkey's body, and the muscular arrangements of its haunch, loins, and hind limbs, are not adapted for the maintenance of the erect posture. Indeed, if we consider for a moment the adaptation of the animal's foot to the uses of a hand, we may readily enough conceive why the erect posture is one for which the monkey-race is absolutely unfitted. Probably any cause which lessened the use of the foot for grasping, would tend towards the development of the powers and faculties through which the erect posture could be assumed. But the entire organisation of the ape militates against the idea that this posture can be readily or easily assumed by the quadrumanous tribes: since not only muscles, but bones also, and indeed the entire framework of the animal, would require to undergo very considerable modification before the human posture could be readily or without effort maintained.

The order of monkeys was included by Linnæus along with the human group under the common designation of *Primates*. To this arrangement, as expressive of real and natural affinities between the two orders, modern zoology has returned. The structural gaps between man and apes may seem wide and yawning to those who do not realise that one and the same type of structure runs unbrokenly through the Vertebrate races, from fish, through frog, reptile, and bird, up to quadruped and man. As the same general type characterises all the Vertebrate animals, so that mere special modification of it which marks the whole quadruped-class is again reflected with equal clearness in forms so divergent as the whale, dog, horse, bat, ape, and man. And as, lastly, the quadruped-form exhibits its own rise and advance as we proceed from its lower to its higher forms, so again we must note that the same high development is reflected not singly in human structure, but conjointly in the quadrumana and in man. In other words, ape-structure is an advance upon that seen in other quadrupeds, but it is an advance in which humanity has shared and beyond which human development has, in turn, proceeded. Only some such ideas as these, which bargain for the idea of an unbroken and continuous development of quadruped-life, and, indeed, of life of every grade likewise, can satisfy the modern scientific aspiration after a true cause at once of life's likenesses and of living variety.

Natural historians have divided the monkey-tribe into three well-known groups. These subdivisions are characterised each by highly distinct variations in structure, and in habits as well. The lowest of the three groups includes animals which are only doubtfully classified

with the monkeys, and which in revised arrangements of the quadruped group will probably receive a different position in that group, and be ranked with lower forms than their present associates. These democrats of the monkey-tribe thus alluded to, are popularly known as "Lemurs" or "Half-Apes," whilst the African species are often named "Madagascar Cats"—so feline is the aspect of their forms. A glance at the lemur-cages in the monkey-house will show that the latter cognomen has not been misapplied. The lemurs constitute the section of the monkey-group, known to naturalists as the *Strepsirhina*—a name readily enough translated into the exact English equivalent of "twisted nostrils." Each of the three main groups of monkeys possesses a well-marked geographical range. The lemurs are thus limited to the Old World, and are limited in their distribution to Madagascar (as their headquarters), Southern Africa, and Eastern Asia. As they exist to-day, the naturalist notes that they merely represent the detached survivals of a once widely-distributed race of animals. In their structure there are to be found very clear traces of affinity with the mole, shrew, and hedgehog order (*Insectivora*), and with the rat order (*Rodentia*) as well. The lemurs walk habitually on their four legs, and their skin is furry or woolly; the body-covering, in this respect, exhibiting a decided variation from that seen in the typical monkeys. No lemur has the "cheek-pouches," seen so familiarly in many monkeys such as the "Bonnet monkey," in which food can be stored. The aspect of a greedy "Bonnet," with its stuffed "cheek-pouches," forcibly reminds the spectator of an unfortunate patient suffering from toothache in each jaw, and presenting the usual swollen addenda of that distressing malady. Again, the lemurs do not exhibit any of those curious bare patches of skin, named "callosities," or "seat-pads," and which are so frequently seen in the Old World monkeys. Their fore-limbs exceed the hind-limbs in length, and the great-toes are always "opposable" to their neighbour digits; that is, can be utilised for hand-like functions. The second toe has a claw-like nail; and the fourth digit, both in hand and foot, is longer than its neighbours. In none of the lemurs do we find the cavities known as "air-sacs," so well developed in many of the monkeys, and by means of which the resonance of the voice is so largely increased. The bones of the face are also prolonged to a greater extent than in other monkeys. A distinctively human characteristic is that seen in the fact that the brain overshadows the face, which is in turn shortened, and not prolonged outwards as in the lower animals. We see the tendency towards face-prolongation in the lower races of mankind, when we compare their skull-conformation with that seen in the higher races. And in the ape-tribe this distinction is also apparent; the higher monkeys possessing shortened facial bones as compared with the lower forms. In the lemurs, the

muzzle also is distinctly pointed, and the face is covered with hair, unlike that of the more typical apes. The tail varies in length. Whilst disappearance and modification of the tail is witnessed in the highest apes, and in the highest life we know, that of man himself, this feature may also be seen exemplified amongst these lowest of the monkey-group. Thus, whilst the lemurs proper, such as the "Ruffed lemur" and "White-fronted" species, possess a long woolly tail, the Loris possesses a short tail, whilst the genus *Nycticebus* is tailless.

Certain peculiarities of structure mark the lemurs in addition to the general characteristics just mentioned. Prominent ears and large eyes are amongst their characteristic possessions. Their teeth vary greatly from the human standard, which is represented in the typical Old World monkeys. But it is at the same time a peculiar fact that in one little lemur (*Tarsius*) found in Celebes and Borneo, a distinctly human character is seen in the want of any interruption or interval between the teeth of each jaw. Such intervals are common enough in quadrupeds, but save the Tarsier just mentioned, and an extinct form—*Anoplotherium*—there is no other known quadruped which exhibits this peculiarity. The Tarsier and certain other lemurs also show a marked peculiarity of structure in that their ankle-bones are much elongated, after the fashion seen in the hind-limbs of frogs and their neighbours. If the foot of a quadruped is lengthened, it is usually the instep-bones which become modified so as to increase the structure. In a few lemurs, as in the frog-group, however, the ankle-bones themselves undergo the process of alteration. It is thus a curious fact that for a parallel to this peculiarity of lemur life we must go backwards to the amphibian class. Such a step, however, it should be noted, by no means implies relationship between quadrupeds and frogs. It merely presents the naturalist with another example of those coincidences in structure which research is continually bringing under our notice, and which have probably arisen entirely independently of each other, through possible similarities in the laws or tendencies which have directed the development of living beings in the past.

One of the most curious forms included amongst the Lemurs, demands a special notice. This is the Aye-Aye or *Chiromys* of Madagascar, which was described in 1780 by Sonnerat. In 1844 it was practically re-described, and in the latter year was brought to Paris. Its anatomy has been specially investigated by Professor Owen. The chief peculiarities of the Aye-Aye are found in its teeth, which differ from those of all other lemurs and all other monkeys indeed, and resemble those of the *Rodents* or "Gnawers." Only one pair of front or cutting teeth exist in each jaw, but these teeth, like the front teeth of Rodents, and the tusks of the elephant, spring from "permanent" pulps. They thus grow throughout life; such a

method of increase making ample provision for their use as gnawing instruments. Like the front teeth of the Rodents, those of the Aye-Aye are covered on their front surfaces with enamel, which being harder than the hinder ivory of which the bulk of the tooth is composed, provides for a sharp edge being continuously kept up on these teeth. As in the Rodents also, no "eye-teeth" are found in the Aye-Aye. The thumb is scarcely opposable to the other fingers, and it has a claw-like nail. The middle is the longest finger, and appears to be specially adapted for picking insect food from beneath the bark of trees. The ears are prominent, and the tail is bushy; the Aye-Aye thus resembling a squirrel in appearance. In its entire structure, we witness a series of modifications adapting it for a life amongst trees, and for an insect-dietary. Its affinities relate it decidedly to the Rodents or rat-tribe and separate it from the lemurs; and the mere existence of this curious form serves to show how the work of modification may proceed apace when the surroundings of an animal favour its departure from the type of its race.

The second great subdivision of the monkey-order is known as that of the *Platyrhini*, or "broad-nosed" monkeys, which, without a single exception, inhabit the New World. In the dense forests of South America these monkeys are thoroughly at home. They are eminently fitted for an arboreal life, and their whole organisation indicates that the modifications to which their race has been subjected have been chiefly directed towards their adaptation for a habitation among the trees. Included within the limits of the "broad-nosed" tribe we find such monkeys as the well-known Marmosets, the Spider Monkeys, the Howlers, and the little Capuchins, whose tricks and gentle ways endear them to all lovers of animals. In many respects the marmosets stand alone amongst the New World forms. Their fur is thick and woolly; they are typically "four-legged" as regards their walking movements; and their tail is long and not adapted for grasping. No cheek-pouches exist, nor are any "callosities" developed. The ears are very prominent and are covered with hairs, whilst the nostrils, as in all American monkeys, are broad and possess a wide "septum," or partition, from the presence of which conformation their "Platyrhine" cognomen is derived. The marmosets possess short front limbs when these members are compared with the hind limbs; but their thumbs are not "opposable" to the other digits, and the essential character of a "hand" is therefore hardly represented in these animals. The thumb, in fact, cannot be separated from the other fingers, and to the great-toe much the same remark applies. The sole of the foot in the marmosets is disproportionately long; and the great-toe is small and provided with a flat nail, whilst the nails of the other toes are curved. The marmosets, as has been

remarked, are not "quadrumanous" in any sense. A curious fact, however, remains to be noted. Although the thumb is "unopposable" to the other fingers, the muscles which, in the typical "hand," give to the thumb its well-known powers of movement, are represented in the fore-limb of the marmosets. Such a fact would seem to indicate either extensive modification of a once-useful hand, or the beginnings and possibilities, under suitable conditions, of hand-like functions being assumed by these animals. In respect of their teeth, whilst the marmosets possess the same number of teeth as man and the Old World apes—namely, thirty-two—these organs are differently arranged from those of their higher neighbours. The marmosets possess four front teeth, two eye teeth, six premolars, and four molars or grinders in each jaw; whereas in man and higher apes four premolars and six molars are found in the jaw-armature above and below. Squirrel-like in appearance, the marmosets resemble these familiar quadrupeds in their habits. They are fruit-eaters, but do not disdain an insect-diet, and they appear to live in families in the trees. Whilst monkeys produce, as a rule, but one young at a birth, the marmosets may produce as many as three. A singular fact of their anatomy is found in the large size of their true brain (or *cerebrum*), the halves of which overlap the lesser brain (or *cerebellum*) so as to cover the latter, when the brain is viewed from above. Such a conformation is usually associated with a high type of brain, but its occurrence in the marmosets does not appear to be accompanied by any special development of intelligence.

The remaining representatives of the *Platyrhinæ*, or New World monkeys, agree in possessing for the most part "prehensile" tails; that is, a tail, the extremity of which can be utilised to grasp such objects as the boughs of trees. The tail may lose this power, as in the Sakis and squirrel monkeys (*Callithrix*, &c.); and it may be short, as in the *Brachyuri*; but no New World monkey absolutely wants the tail—a condition typically seen in certain of the Old World apes. In such monkeys as the *Ateles*, one of the spider monkeys, and the howlers (*Mycetes*), the tail attains its highest development as a prehensile organ. It is less powerful in the little Sapajous or Capuchins. So powerful is the tail in the Ateles, that its designation of a "fifth hand" is seen at once to be well merited. By its aid, this monkey can suspend itself from the bough of a tree, with hands and feet free to grasp any object and useful for the performance of any function. It is naked beneath at the tip in the Ateles, and thus serves the more efficiently as an organ of seizure; whilst in the Capuchins the tail is hairy at the extremity. The adaptation to a life amongst trees, is well seen in such a conformation as that found in the tail of these Platyrhine monkeys. That such adaptation has been of general and universal character is proved by the fact that

other quadrupeds of the continent exhibit similar or analogous structures assisting the free exercise of an arboreal life. The sloths illustrate forms which have been thus modified, and the American porcupines also possess prehensile tails which are unknown in their Old World neighbours.

No New World monkey possesses either cheek-pouches or callosities, and the ears are bare in the typical forms now under consideration. In most of these monkeys, the hind limbs are longer than the fore limbs; but in the spider monkeys the latter exceed the hind limbs in length. As regards the hands and feet, the thumb on the whole is less specialised and distinct from the other fingers than in the Old World apes. The great-toe is large and possesses very free powers of movement, but the thumb can hardly be said to be "opposable." In the spider monkeys, the perfection of tail appears to be counterbalanced by the rudimentary condition of the thumb. A well-known form, the Coaita, has no thumb at all; and the Chameck possesses the merest vestige of this digit. But, strange to say, whilst the thumb in these cases is rudimentary, all the characteristic muscles which move it in other forms are represented. Such a fact would appear to point to the degradation of the thumb, and to its functional abrogation and probable disappearance from the hand of the spider monkeys. In due time the thumb-muscles now represented, may also be expected to disappear It would seem, indeed, as if the "balance of power," which forms a ruling principle in the world political, was also an important factor in the world of life. The extreme development of the tail to serve the functions of a hand may, perhaps, legitimately enough, be credited with having played a part in the modification of the thumb of these apes.

In the New World monkeys, the teeth differ in number from those of man and of the Old World apes. Thus, whilst the latter possess thirty-two teeth, the Platyrhines are provided with thirty-six—the presence of an additional premolar tooth on each side of each jaw accounting for the increase in number. In respect of their diet, the American monkeys are, for the most part, fruit-eaters, although some species appear to eat insects as a regular part of their dietary. In form, size, and appearance, as well as in many details of their internal anatomy, the New World monkeys exhibit immense variations. Thus, for example, the brain varies greatly in different members of this group, both in respect of absolute size and of relative development. Some are smooth-brained (*e.g.* squirrel monkeys); whilst others (*e.g.* Sapajous) possess convoluted brains. If the doctrine that complexity of brain-convolutions bears a direct relation to the intelligence of the animal be true, we may possibly on this ground account for the remarkable intelligence of the Sapajous, as on the same ground we

may account for the increased and special mental calibre of man himself.

The special features of the Platyrhine apes are so numerous, that the most superficial notice of the more prominent forms can alone be attempted here. The howlers (*Mycetes*), for example, derive their popular name from their loud voice, which resounds for immense distances through the South American forests. These monkeys are the largest of the New World apes, and their special peculiarity consists in the possession of a bony "drum" connected with the *larynx* or organ of voice. Through this drum, which acts like a sound-chamber, the voice of the Mycetes is rendered trebly powerful, and resounds through the Amazonian forests for miles. The agile spider monkeys of America remind us of the gibbons of the Eastern Archipelago in their agility and in the possession of long slender limbs. It is the spider monkeys which are credited with linking themselves together from the bough of a tree by the fore limbs and tails so as to form one animated chain. This chain is then set swinging until the individual which represents the end of the chain is enabled in the course of the oscillations to grasp the branch of a tree on the opposite side of the river or ravine which the tribe desires to cross. Amongst the Sakis certain very curious features in the hairy covering of the body are to be noticed. One form, the Couxio, possesses a well-developed beard, which, being of a deep black hue, gives to the monkey a most singular appearance. The Yarké presents a still more curious feature in that the head of the females alone is covered with long hair. Another form is bald-headed, and possesses a rubicund face, whilst the body is covered with white hair. The night monkeys (*Nyctipitheci*) possess the face surrounded by a ruff of hair, and the eyes, as is usual in animals of nocturnal habits, are of very large size.

Turning now to the last group of the monkey-order, we find the apes of the Old World (excepting the lemurs already noticed) to be included in the division known as that of the *Catarhina*. This latter name has reference to the oblique or slanting conformation of the nostrils in these apes. The nostrils, as one may readily see on looking at a baboon, a bonnet monkey, or a common macaque, slope from the brow to the lips. They are placed close together, and the broad partition seen in the New World apes is replaced by a narrow one. We enter the domain of the "anthropoid," or man-like apes, when we commence the investigation of the Catarhine monkeys. It is in this group that we certainly discover the nearest approach to human structure as a whole; although it should not be forgotten that this division includes forms of widely varying degrees of organisation, and by no means exhibits a uniformly high structure through-

out its extent. The characters of the group are readily discoverable. In addition to the oblique nostrils, we find that Old World monkeys possess the arrangement and number of teeth seen in man himself. The tail may be long, short, or rudimentary, but in no case is it "prehensile"; and the Old World apes are thus seen to want one of the chief characters of their New World neighbours. In this group also, cheek-pouches are common, and the bare patches, "seat-pads" or "callosities," already alluded to, are frequently developed.

The Catarhine apes fall into two natural divisions, of which the first includes by far the vast majority of these animals; whilst the second division contains the aristocracy of the ape-group in the shape of the four highest forms—namely, the Gorilla, Chimpanzee, Orang, and Gibbons. The first or lower division is represented by the great race of the Macaques, of which the common Macaque or Jew Monkey (*Macacus cynomologus*) and the Bonnet Monkey (*M. radiatus*) are the most familiar forms. Also included in this group are the Semnopitheci, the long-tailed Indian monkeys, of which the *Semnopithecus entellus*, or the Sacred Monkey of the Hindoos, is a familiar example. Africa possesses many representatives of the lower Catarhine apes. The genus *Colobus* is a notable African group, distinguished as the only Catarhine tribe in which the thumb is rudimentary. The Gibraltar ape is a species of Macaque (*M. Inuus*), and an allied form (*M. speciosus*) is found in Japan. The curious Proboscis Monkey (*Presbytis nasalis*), known by its elongated nose, and found in Borneo, belongs to the group under review; as also does the *Cercopithecus* genus, including long-tailed African monkeys. Indeed, all the smaller monkeys of the Old World are zoologically located in this subdivision of the Catarhine group. The Macaques are limited in their distribution to Asia, and possess both "cheek-pouches," well-developed thumbs, and "seat-pads." Their tails vary in length, being long in some species, but short and rudimentary in others. These monkeys naturally walk on all-fours, and present in this respect a marked variation from their higher neighbours. The baboons may also be regarded as belonging to the present group, although they possess certain special characters, which, in the opinion of some zoologists, serve to separate them from the smaller monkeys of the Old World. The name *Cynocephali*, or "dog-headed," applied to the Baboon-group, indicates that their skull is more "brutal" in its characters than that of their neighbour apes. Their jaws project to an extent unknown in the smaller forms, and the dog-like aspect of the head forms indeed one of their most readily-recognised features. The tail is short, and may be rudimentary. The "eye-teeth" are specially prominent, and remind the observer of the similar teeth in carnivorous animals. The "seat-pads" are, as a rule, brilliantly coloured, and the cheek-pouches are

large. Whilst the baboons possess well-developed thumbs, and whilst the legs are nearly of equal length, they seem to walk on all-fours more persistently perhaps than any other apes. In habits they are fierce and predatory, and are said to associate themselves together in bands, which make common cause in the case of attack upon or defence from an enemy.

The second and higher division of the Catarhine Apes introduces us to four forms, ranked by naturalists under three genera. These forms are the Gorilla and Chimpanzee (*Troglodytes*), the Orang (*Pithecus*), and the Gibbon (*Hylobates*). The two former inhabit Western Africa, whilst the orang is found only in Borneo and Sumatra, and the gibbons in Eastern Asia and the Malay Archipelago. Of the three groups, the gibbons are those most nearly related to the other monkeys of the Old World. They alone possess seat-pads, and only the nails of the great toes and thumbs are broad. The orang, gorilla, and chimpanzee do not possess "seat-pads," and all the fingers and toes possess flat nails. Regarding the higher apes, including the gibbons, as a whole, we see in these animals a tendency towards the semi-erect posture which is not habitual in other monkeys. When an orang or gorilla assumes the posture in question, it supports the weight of its body upon the knuckles of the fingers; and it is in the higher apes alone that this highly characteristic position is assumed. No tail is developed in these apes, and it is important to note that the muscles of the tail are of rudimentary nature; this latter fact indicating that the modification of the caudal appendage has been by no means a recent event in the history of these apes. The thigh and leg are shorter than the arm and forearm respectively. The teeth do not merely resemble those of man in number and arrangement, but even present a close likeness in the special development and proportions of the human teeth above and below. The gibbons themselves are most notable for the extraordinary length of their arms. The tips of the fingers touch the ground when the animal stands erect. These apes not merely stand erect with ease, but run swiftly and without effort. Like the spider and howler monkeys of the New World, the gibbons spend their existence amongst the forests of Eastern Asia and the adjacent Archipelago. Their long arms enable them to swing from one branch to another with the greatest possible ease; and we may thus observe how Nature adapts different creatures by varied means for a similar or allied life. It is chiefly to the prehensile tail that the New World monkeys owe their dexterity in their forest flights; whilst the equally agile gibbons, possessing no tail, find in their elongated limbs the necessary adjuncts for an existence amongst the trees.

The orang is perhaps one of the most celebrated of apes. The average height is about four feet and a half. The arms are relatively

long, but the legs are by no means disproportionately developed. The thumb and great-toe are shortened, and the foot cannot be placed flat on the ground. The orang is a vegetable feeder, and appears to be of quiet and peaceful disposition, although, when driven to bay, as in incidents related by Mr. A. R. Wallace, this ape may prove itself to be a most formidable opponent. The chimpanzee and gorilla are included in one genus (*Troglodytes*), and inhabit the same region, namely, the intertropical parts of Western Africa. The gorilla (*Troglodytes gorilla*) is by far the largest of the man-like apes; the average height being about five feet, or even more. The erect posture is readily assumed by the gorilla, the foot being broad, and capable of supporting the weight of the body. The aspect of the gorilla is both terrifying and repulsive. The great shaggy head; the over-arching eyebrows and their ridges; the full glaring eyes; the prominent and widely separated nostrils, and the implied muscularity of jaws and body, justly serve to render this great ape a formidable antagonist to his higher neighbour, man himself. The two living specimens of the gorilla which I have had the opportunity of inspecting were both young forms. One of these was the famous "Pongo," which was exhibited in London some years ago. The other specimen was a still younger gorilla, whose acquaintance I made in Liverpool in 1881. Both specimens were tame, "Pongo" being particularly playful and demonstrative. But even in the young condition, there was no mistaking the air of latent ferocity which these apes possessed; and the uncertain tempers of each specimen bore testimony to the strongly and purely animal nature which a few additional years would doubtless have developed in all its typical strength. The chimpanzee (*Troglodytes niger*) attains an average height of four and a half feet, and is usually larger than the orang. In many respects, and especially in its mental aspect, this ape is the most man-like of the anthropoid species. The erect posture is readily assumed either in standing or in walking; and the habitual attitude of these apes, namely, that of resting on the knuckles, is perhaps most typically seen in the chimpanzee. The thumb and great-toe exhibit a full development.

Summing up the characters of these man-like apes in which they respectively approach the human type of structure, comparative anatomy declares firstly, that the gibbons, of the three genera, are furthest removed from man's order. The orang exhibits the nearest approach to man in the shape of the *cerebrum* or brain proper, and in the number of ribs. The gorilla most resembles the human subject in the shape and curves of its spine, and in the form of the pelvis or haunch. The actual size of the brain-case in the gorilla, also comes nearest of all the apes to that of man; and in the size of the heel, as well as in the proportions which its leg bears to its body, and its foot to its hand, this great ape is most

human. The gorilla and chimpanzee possess each 13 pairs of ribs; the gibbons may have 14 pairs; whilst man and the orang possess but 12 pairs. Occasionally a thirteenth pair of ribs, however, is found to be developed in the human subject. The chimpanzee, lastly, most closely approaches to man in three points; namely, in the general characters of the teeth, in the characters of its skull, and in the relative size of its fore limbs. All three groups of apes agree with man in possessing a flat and broad breast-bone, whence is derived the name of "latisternal" apes, often applied to them. It is also an interesting fact that, when young, the head of the orang closely resembles that of the average European infant. As adult life is attained, however, the bones of the face in this ape assume their characteristic shape. They become prolonged forwards, beyond the brain-case; whilst in the human subject the face does not undergo any marked elongation, and, as already noted, is overshadowed by the brain.

The foregoing description of the chief divisions of the monkey-group will serve to familiarise us with the natural constitution of the Quadrumanous family, and will also enable us to study to greater advantage the important question of the mental attributes and general mental development of these interesting animals. A naturalist, whose opinions are deservedly treated with the respect with which his eminence as a scientist naturally invests his ideas, has recently declared that the monkey-race as a whole is much too highly placed in the group of quadrupeds. The writer in question, Mr. A. R. Wallace, remarks, that whilst the monkeys form an isolated group of animals, they also show relations to the lower mammals. Mr. Wallace also adds, that these relations open up the question whether the position of the monkeys at the head of the mammals "is a real superiority, or whether it depends merely on the obvious relationship to ourselves. If," continues Mr. Wallace, "we could suppose a being gifted with high intelligence, but with a form totally unlike that of man, to have visited the earth before man existed in order to study the various forms of animal life that were found there, we can hardly think he would have placed the monkey-tribe so high as we do. He would observe that their whole organisation was specially adapted to an arboreal life, and this specialisation would be rather against their claiming the first rank among terrestrial creatures. Neither in size, nor strength, nor beauty," continues Mr. Wallace, "would they compare with many other forms; while in intelligence they would not surpass, even if they equalled, the horse or the beaver. The Carnivora, as a whole, would certainly be held to surpass them in the exquisite perfection of their physical structure, while the flexible trunk of the elephant, combined with his vast strength and admirable sagacity, would probably gain for him the first rank in the animal creation."

Again, Mr. Wallace remarks that "if this would have been a true estimate, the mere fact that the ape is our nearest relation does not necessarily oblige us to come to any other conclusion. Man is undoubtedly the most perfect of all animals, but he is so solely in respect of characters in which he *differs* from all the monkey-tribe —the easily erect posture, the perfect freedom of the hands from all part in locomotion, the large size and complete opposability of the thumb, and the well-developed brain, which enables him fully to utilise these combined physical advantages. The monkeys have none of these; and without them the amount of resemblance they have to us is no advantage, and confers no rank." Remarking next that we are too much biassed by the considerations of the man-like apes, Mr. Wallace adds that the remaining monkeys would probably be classified in a lower group than that in which they are at present included. "We might then dwell more on their resemblances to lower types—to rodents, to insectivora, and to marsupials, and should hardly rank the hideous baboon above the graceful leopard or stately stag. The true conclusion appears to be," says Mr. Wallace, "that the combination of external characters and internal structure which exists in the monkeys, is that which, when greatly improved, refined, and beautified, was best calculated to become the perfect instrument of the human intellect, and to aid in the development of man's higher nature; while on the other hand, in the rude, inharmonious, and undeveloped state which it has reached in the quadrumana, it is by no means worthy of the highest place, or can be held to exhibit the most perfect development of existing animal life."

The foregoing statements are deserving of close attention, not only because they proceed from a naturalist of high reputation, but because they present certain ideas concerning the place and position of the monkey-tribe which are susceptible, in my opinion, of very important modification, if not of absolute refutation, in certain respects at least. When Mr. Wallace speaks of the monkeys as not comparing in size, strength, or beauty with many other forms, and as not surpassing, even if they equal, the horse or the beaver in intelligence, we may well question whether his statements are not open to legitimate denial. If the collective strength of any group of quadrupeds—save perhaps such an exclusively limited order as the elephants—is taken into account, it may be maintained that such a group will inevitably present its weaklings as well as its giants to the view of the naturalist. If the lower monkeys, or even the intelligent Old World forms, are by no means physically strong, we must not forget that the monkeys own not only their powerful baboons, which may well rival the Carnivora in strength, but also the gorilla and orang, whose physical power ranks extremely high. But it may fairly be objected that strength is no criterion of zoological rank; and I

would add, neither can we take beauty into account in arguments concerning the zoological position of the apes; although Mr. Wallace apparently forgets that amongst the monkeys, and in New World groups especially, there are species to which the terms beautiful and comely may with all justice be applied. The birds are more beautiful than most quadrupeds: and an elegant kangaroo would certainly be preferred by the æsthetic eye to the hippopotamus, rhinoceros, giraffe, or elephant. If we reject strength and beauty, there remains, according to Mr. Wallace, "intelligence" as a criterion of monkey rank. I shall presently endeavour to show that in this latter respect the apes must claim to rank high in the mammalian scale. But I would fain ask those who offer us the alternative of the horse, elephant, and dog, as examples of sagacity and intelligence, whether they are not choosing illustrations to which there exists a grave logical objection on the score of unequal comparison. That dogs and horses owe their sagacity and intelligence to human culture, and to continual association with man, cannot I think for a moment be questioned. Every horse and dog is really reaping to-day the cumulative benefit of a civilised ancestry, so to speak. When we speak of the intelligence of these animals, we must bear in mind, if we are to gain the credit for logical consistency, that this intelligence has been developed and fostered through their employment by man, and through their ministering to his wants, and their participation in his works. It would, in truth, be a thing to excite our wonder, if the horse and dog did not exhibit the intelligence we see illustrated in their family circle. We can hardly fail to own—and the result of my own observations, to be presently noted, serves to support the contention—that had the apes and monkeys been domesticated by man, and had they possessed the advantage of continual association with him, their intelligence and sagacity would have far exceeded that of any other animal group. What I certainly maintain, and what the study of monkey life demonstrates, is that the wild and untrained monkey, when compared with the wild horse, dog, or elephant, is a creature of higher brain-power and greater intelligence than these latter animals. To argue otherwise would simply amount to the assertion of the incongruous statement, that an animal, such as an orang or chimpanzee, a bonnet monkey or a capuchin, possessing a type of brain nearly allied to that of man, would, when its kind was domesticated, exhibit less intelligence than a quadruped which, like horse or dog, possesses a brain far removed from that of man in respect of its development.

It is difficult to reconcile the first part of Mr. Wallace's conclusion with his final words. "The combination of external characters and internal structures" which is seen in the monkeys, and which, Mr. Wallace rightly remarks, is that which under a higher guise makes

the sum-total of human life and structure, is also said to exist in the apes in "a rude, inharmonious, and undeveloped state." If even we admit the justice of the latter statement—and I am very far from making any such admission—it is scientifically tenable, that, however "rude" or "inharmonious" the characters and life of the apes, as a class, may be, from allied or similar characters the higher human life has been evolved. As a matter of fact, there is no combination of characters to be found in any other group of the quadrupeds more harmonious or more elaborated than that seen in the apes. If the actual structural perfections of the monkey-tribe be taken into account, it will be found, I think, on the whole, to excel that of any other group of mammals. There is practically no order of the quadruped class which does not include within its limits beings of low and high organisation. Hence in all comparisons of the ape order with other orders of animals we must take this fact into account; and it is exactly this latter consideration which Mr. Wallace seems to me to have tacitly ignored. Leaving the highest apes out of the question, it may be shown, that in the monkey-tribes which people the Old and New Worlds, there are represented characters, both of body and mind, which certainly equal and often excel anything we find in dogs, horses, elephants, or other animals. Lastly, if we even consider the ways and works of the lowest races of men, we may discover that the sphere of humanity itself may be found to include much that is the reverse of harmonious, and many features which represent the antipodes of beauty. Beyond all such considerations, however, there remains the plain contention that, as a group, the apes exist at the upper confines of the quadruped class, and that, in their mental phases, they fully realise the utmost expectations of the naturalist. To quote the words of Dr. G. J. Romanes, "Notwithstanding the scarcity of the material which I have to present, I think there is enough to show that the mental life of the *Simiadæ* is of a distinctly different type from any that we have hitherto considered, and that in their psychology, as in their anatomy, these animals approach most nearly to *Homo sapiens*." To the investigation of the mental phases of ape character, we may now direct our attention.

Some three years ago, I began to keep a number of monkeys in confinement in a large and roomy cage in my house. I instructed my servants to note carefully any special actions of the monkeys which they might observe; and the animals were also watched from day to day by members of my family circle on whose accounts I could place implicit reliance. I may add, that in nearly every instance I have been able to verify the observations of others regarding the habits of my pets. The first two monkeys I selected for domestication were purposely chosen of widely different species,

in order that I might be presented with an opportunity of comparing their habits. These two first additions to my family circle consisted of a clever little Bonnet Macaque (*Macacus radiatus*), who was duly named "Jenny," and a Brown Capuchin (*Cebus fatuellus*), who was christened "Paddy," from certain facial characteristics which suggested the appropriateness of an Hibernian cognomen. I soon added to these two monkeys, a third—a somewhat aged common Macaque (*Macacus cynomologus*), which I obtained from the keeper of a public-house in the North of England, and whose deteriorated habits in the way of a fondness for becoming intoxicated on beer would have merited the reprobation of a temperance reformer. A visit to Jamrach's resulted in the purchase of a very fine Sooty Mangabey (*Cercopithecus fuliginosus*), which was named "Cetchy," from a decided resemblance borne by this monkey to the Zulu Chief. At varying intervals, when death had thinned the ranks of my monkey-family, I bought other two common Macaques, respectively named "Rosy" and "Polly"; another Bonnet Monkey, "Salaam" (so named from his habit of salutation), and a second beautiful Brown Capuchin (*Cebus fatuellus*), known as "Sammy."

The careful observation of these monkeys convinced me that the opinion I had before formed of the varying mental powers to be found amongst the individuals even of one and the same species was a thoroughly correct one. Thus, to select the two bonnet monkeys, "Jenny" and "Salaam," I found that, whilst the former exhibited (and I ought to say still exhibits) a high intelligence and acute perception, the latter was dull and even stupid, and could with difficulty be made to perform such simple acts as the other monkeys readily understood. After noticing how varied were the mental powers of my monkeys, I could the better realise the force of the illustration which Mr. Darwin cites in his "Descent of Man" regarding the variability of the faculty of *attention* in monkeys. Mr. Bartlett, of the Zoological Gardens, informed Mr. Darwin that "a man who trains monkeys to act in plays used to purchase common kinds from the Zoological Society at the price of five pounds for each; but he offered to give double the price if he might keep three or four of them for a few days in order to select one. When asked how he could possibly learn so soon whether a particular monkey would turn out a good actor, he answered that it all depended on their power of attention. If, when he was talking and explaining anything to a monkey, its attention was easily distracted, as by a fly on the wall or other trifling object, the case was hopeless. If he tried by punishment to make an inattentive monkey act, it turned sulky. On the other hand, a monkey which carefully attended to him could always be trained." Mr. Darwin, remarking on the diversity of the mental faculties in men of the same race, says, "So

it is with the lower animals. All who have had charge of menageries admit this fact: we see it plainly in our dogs and other domestic animals. Brehm especially insists that each individual monkey of those which he kept tame in Africa had its own peculiar disposition and temper. He mentions one baboon remarkable for its high intelligence; and the keepers in the Zoological Gardens pointed out to me a monkey, belonging to the New World division, equally remarkable for intelligence. Rengger also insists on the diversity in the various mental characters of the monkeys of the same species which he kept in Paraguay; and this diversity, as he adds, is partly innate and partly the result of the manner in which they have been treated or educated." My own experience endorses these opinions; but I believe that innate disposition, and not education or training, is the chief factor in producing the particular mental character of any given monkey.

I thoroughly agree with Dr. Romanes in his declaration that in monkeys "affection and sympathy are strongly marked—the latter, indeed, more so than in any other animal, not even excepting the dog." The monkey "Jenny" in particular exhibited a strong affection for myself, and likewise showed a maternal care of her neighbours in the cage. The instance given by Mr. Darwin, and already quoted, of the little American monkey who rushed to the rescue of the keeper who was attacked by a baboon, appears to me to illustrate a common trait of monkey-character. When any one, and even a person for whom "Jenny" showed a liking, made believe to strike me, "Jenny" would rush to the front of the cage, would shake the door, snarl and cry, and exhibit the most intense rage. If liberated, she would rush to bite the offender, flying generally at the face, but invariably retreating to my arms to be fondled, and to be quieted by gentle stroking and soothing words. Any attempt to renew the offence was at once followed by renewed rage and defensive attitudes. Mr. Darwin remarks the fact noticed by Mr. Sutton, that the face of the *Macacus rhesus*, when much enraged, grows red. Mr. Darwin himself saw the face of this monkey redden when attacked by another monkey; and he also adds that the "seat-pads" also seemed to redden under the influence of anger, although he could not "positively assert that this was the case." My monkey "Jenny," when in a rage, blushed most distinctly. A red hue shot over and obscured the normal yellow tint of the skin of the face, and I noticed that the "seat-pads" occasionally also grew redder. Another curious fact concerning this monkey's behaviour when enraged consisted in the variations she exhibited when she was irritated by myself and by another person. If irritated by another person, she behaved as already described; she shook the cage and chattered, whilst her face flushed

like that of a human being in anger. If, on the other hand, I had occasion to reprove her, she darted down to the bottom of the cage, lay down on her belly, and, as often as not, concealed her face in the straw. The analogy between that ineffective or suppressed rage in a human being, which is shown by the person throwing himself down on the ground—a feature seen familiarly in some children—and the behaviour of "Jenny," under my reproof, appears to me to be too exact to escape notice. "Paddy," the Capuchin, on the contrary, when enraged or frightened, used to retire to a corner of the cage and stand on his head, uttering meanwhile the most plaintive cries in the well-known shrill but musical voice of the race. On one occasion, when a servant had allowed "Paddy" to imbibe nearly half a glassful of champagne, he showed his alcoholic dissipation by standing inanely on his head and vainly endeavouring to emit his familiar cry. Mr. Darwin mentions the case of a young female chimpanzee, who, when enraged, "presented a curious example to a child in the same state. She screamed loudly with widely open mouth, the lips being retracted, so that the teeth were fully exposed. She threw her arms wildly about, sometimes clasping them over her head. She rolled on the ground, sometimes on her back, sometimes on her belly, and bit everything within reach."

A curious fact in connection with the expression of rage by my monkeys is to be noted in the different fashions in which the emotions were exhibited. "Jenny," when enraged, chattered; her ears were depressed, her brows were wrinkled, and her teeth were fully exposed, as in the chimpanzee above described. When "Mammy," the old macaque, or "Polly" was enraged, she showed her anger chiefly by protruding the lips to an extreme degree, in an exaggerated pout, and in trumpet-fashion, giving vent to a sharp, short "hooh." Mr. Darwin gives a drawing of a sulky chimpanzee in his "Expression of the Emotions" (page 141, tenth thousand), which accurately represents the act of the common macaque when enraged. The varied methods of thus expressing the emotions in nearly related monkeys constitutes in itself a powerful argument in favour of the advance of mental evolution even within a limited range. Amongst the ingenious expedients of my monkeys, in the way of utilising their surroundings for various purposes, may be mentioned the feat performed by "Polly," the little macaque, of utilising the bars of the perch as a gymnastic pole, around which she, in company with "Jenny," used to spin, like an agile acrobat, for lengthened periods. "Polly," more ingenious still, used to twist the straw of her cage into a rope. This she attached to one of the projecting bars of her perch, and then, seizing the extemporised rope, would swing round and round after the fashion of a roasting-jack; evidently utilising and enjoying the recoil of the straw as a means of continuing her amuse-

ment. A more difficult feat was that of "Polly," in her imitation of an acrobat, in a backward spring. Jumping forwards from the perch to the side of the cage, she sprang backwards, and in an instant regained the perch. "Jenny" was observed to watch the performance of this feat with interest, and to essay its execution; but her attempts were clumsy and unsuccessful when compared with those of her more agile neighbour.

The trait of *curiosity* has, of course, been frequently noted as a prominent mental character of most monkeys. I can vouch for the fact that my entire monkey-family became at once interested in any novel or unusual operation which was being carried on in the kitchen in which they resided. "Jenny" in particular, and the others in a less degree, were also extremely quick to notice any new article of attire which the members of my household might exhibit. Articles of jewelry, seen for the first time, attracted especial notice. A new pair of earrings, or a new cap, was at once recognised as novel; and efforts were usually made to grasp the desired object. Strangers introduced to the monkeys were often surprised at the varying receptions they received. I soon noticed the curious fact that certain persons were received from the first with dislike, whilst others apparently made a favourable impression on the inmates of the cage. One individual appeared to be hated by the collective cage; whilst another friend was played with and evidently fondled by "Paddy," the capuchin, who as a rule was singularly shy of strangers. For a dead newt from my aquarium, or a live grass-snake, the entire cage entertained an extreme horror. The mere sight of the snake elicited screams from the whole family, and a retreat to the sleeping box was the invariable result of the ophidian's appearance. The abhorrence exhibited by monkeys for snakes is, of course, a perfectly natural instinct of these animals; in their native haunts, they must learn to fear and avoid these reptiles. "Sammy," the capuchin, exhibited a high degree of curiosity, and performed a large number of clever tricks. He played with a ball like a child; shook hands with visitors; and when provided with a cloth and water, he washed his dish, a feat also performed by a capuchin named "Tommy," which lived for a very short time only in my possession. "Sammy," if furnished with a hammer and tacks, duly utilised both in the familiar fashion, thus showing a faculty of imitation of the purest kind.

Various writers have spoken of the behaviour of monkeys to their ailing and dead companions. Mr. Darwin gives instances of the grief of female monkeys for the death of their young. Certain female monkeys kept by Brehm, in North Africa, died from grief consequent on the death of their young. An instance is narrated in which a female monkey having been shot, the leader of the troop came to the door of the tent and mourned for the body, after indulging in a

series of threatening gestures. The body was given him, and thereafter he retreated, bearing it away with every expression of sorrow in his arms. The Gibbons are said to attend carefully to injured companions, but to take no notice of dead friends. A monkey has also been known to extend a cord to another which had fallen overboard from a vessel. I observed that when one of their dead companions was shown to the remaining occupants of my cage, they did not appear to be frightened, but seemed to regard the dead body with indifference, and to exhibit very little curiosity on seeing the still form of their companion. When, however, one of the family was ailing, the others paid it a great amount of attention, not always, so far as I could see, of a friendly or sympathetic nature. When "Paddy," the capuchin, was ill, and in fact just before his demise, his friends appeared to me to endeavour to raise him from the recumbent posture in which he lay. Whether this was done in anxiety for the sufferer, or from mere curiosity, I am unable to say. Perhaps both ideas animated the survivors in their attentions to their sick friend.

On one occasion I observed in "Cetchy," the sooty mangabey, a singular example of what I conclude may legitimately be called the reasoning faculty in the truest sense of that term. Seeing his anxiety to obtain a small piece of apple which I held in my hand, I resolved to test his powers of reason and of discrimination in the following way. I showed him the piece of apple, and as he tried to grasp it I allowed it to slip down the sleeve of my coat, after the familiar fashion of the childish conjuring trick. "Cetchy" viewed the disappearance of the apple with surprise, and minutely examined my hand—unclosing my fingers, to see if I had concealed it therein. Allowing the morsel to again come into view, but being careful to avoid showing its place of concealment, I again passed it up my sleeve. "Cetchy" again narrowly examined my hand, turning it over so as to see the back of the hand, but of course without success. The peculiar dissatisfied grunt with which "Cetchy" greeted his want of success was both characteristic and amusing. I then repeated the operation for the third time, when "Cetchy" at once, and without examining my hand again, passed his hand into my sleeve, and extracted from its hiding-place the coveted morsel, which I may add was entirely concealed from the monkey's view. As time passed, it is important to note that "Cetchy" did not trouble himself to investigate the hands in search of the missing apple. Repetition of the trick acquainted him with its *rationale*, and his hand went directly to the sleeve for the coveted morsel. In this case we may, I think, safely conclude that the hiding-place of the morsel was first detected simply by an exercise of that common and tacit "reason" through which we ourselves gain a knowledge of the unknown. In

the human subject, it is almost needless to add, such "reason" may be exercised as unconsciously as, no doubt, it was put in force by the mangabey.

Recognition of friends and places, through the exercise of *memory*, is a faculty eminently possessed by monkeys. A baboon recognised Sir Andrew Smith at the Cape of Good Hope, after an absence of nine months. "Sammy," the capuchin, was deposited by me in the Zoological Society's Monkey-house, and was visited thereafter by several friends and myself at intervals. The friends were resident in London, and, as they saw him at tolerably frequent intervals, it was not surprising that he should at once recognise them on their entering the Monkey-house. My first visit to "Sammy" was paid after an interval of between two and three months. I approached his cage amongst the crowd of visitors and waited. "Sammy," at that moment, was perched high up on a cross-bar. All at once he apparently spied me; for rushing down with a scream of joy, he came to the spot where I stood, and, thrusting his hands through the bars of the cage, embraced my hands in his own, and screamed so loudly that the keeper hurried round in alarm to investigate the cause of the commotion. At frequent intervals, I was similarly recognised; indeed, up to the date of his death, the memory of this kind little monkey was active and clear, as his affection for his friends was unabated. My experience agrees with that of Mr. Romanes described in his recent work on "Animal Intelligence," from which I quote the following account: "I returned the monkey" (a Brown Capuchin), says Mr. Romanes, "to the Zoological Gardens at the end of February, and up to the time of his death, in October 1881, he remembered me as well as the first day that he was sent back. I visited the monkey-house about once a month, and whenever I approached his cage he saw me with astonishing quickness—indeed, generally before I saw him—and ran to the bars, through which he thrust both hands with every expression of joy. He did not, however, scream aloud; his mind seemed too much occupied by the cares of monkey-society to admit of a vacancy large enough for such very intense emotion as he used to experience in the calmer life that he lived before. Being much struck with the extreme rapidity of his discernment whenever I approached the cage, however many other persons might be standing round, I purposely visited the monkey-house on Easter Monday, in order to see whether he would pick me out of the solid mass of people who fill the place on that day. Although I could only obtain a place three or four rows back from the cage, and although I made no sound wherewith to attract his attention, he saw me almost immediately, and with a sudden intelligent look of recognition ran across the cage to greet me. When I went away he followed me, as he always did, to the extreme end of

his cage, and stood there watching my departure as long as I remained in sight." More recently, "Jenny," the macaque, at present resident in the Zoo', has recognised me, although with less demonstration than "Sammy" exhibited. "Polly," the little common macaque, on my first visit after her translation to the Zoo', rushed from the centre of the cage on seeing me, without my having in any way attracted her notice, and stretched her hand out as if in friendly recognition.

An interesting and every way affecting incident occurred in the experiences of two little Hamadryad baboons, which I kept at home for a short period. Owing to the baboons being persecuted by the other inmates of the cage, I removed them from the large cage and confined them in a smaller habitation. One afternoon, the male baboon being taken ill, I removed him from the society of his partner, and placed him in a basket near the fire for the sake of the warmth. The female, left in her cage, began to utter low whines of complaint, and appeared to be distressed at the enforced separation from her partner. The male was left for the night in his basket. In the morning, being sufficiently recovered, he was restored to the cage. Immediately on his entrance he was seized by his partner, who placed her arms round his neck, stroked his face, and exhibited the liveliest affection at his restoration to his domestic hearth. Anything more affecting, or more exactly imitative of human affection, could not have been imagined; and the occurrence of such a trait of character in the baboons seems to show that these "hideous" animals, as Mr. Wallace terms them, are by no means destitute of at least some share of the cerebration of higher forms.

That the full mental and social history of the apes has yet to be written admits of no doubt; and that renewed and extended observations will more than repay the labour of the naturalist is an idea which is confirmed by the knowledge already at our command. On the whole, I maintain that the intelligence of monkeys is, firstly, of a markedly human type in most respects; whilst, secondly, their mental life appears to me to represent that of the childish stage of human mind-development. In many of the acts of certain monkeys we see a picture of human life and manners at a stage before reason has asserted her full sway over the actions of the individual, and when such traits and faculties as curiosity, imitation, wonder, &c., are prominently represented in our existence. As the naturalist maintains that certain animals represent "permanent larval forms" in the groups to which they belong, so the monkeys may be held to illustrate a permanent embryo or initial stage of that higher life seen in man—a life built up, confessedly, of emotions; traits and faculties often seen in germ-form in groups of quadrupeds of lower rank than that held by the despised apes. The close observation of the ape-tribe, in fact,

tends to demonstrate that, instead of our being led to rank these animals as psychically low, and as taking a humble place in respect of their intelligence, we must assign to them the highest rank among quadrupeds, when judged by the standard applied to other animals, or even to man himself. It is no wild dream, but a sober vision of science, that the causes which have tended to raise the ape-family in the scale of being, are largely identical with those to which man owes his proud designation as "the paragon of animals."

IV.

ELEPHANTS.

THE interest which attaches to the modern representatives of the mammoth host is by no means limited to the zoological world, but extends throughout all classes of society, who find something to wonder at even in the huge proportions and ungainly ways of the elephant family. A remarkably limited family circle is that which includes the elephants as its typical representatives. The past history of the race, like that of not a few other groups of animals and plants, is exactly the converse of its present-day phases, as regards numerical strength at least. As the existing pearly nautilus is the sole survivor of the immense hordes of four-gilled and shelled cuttlefishes which swarmed in the primitive seas and oceans of our earth; or as the few living "lampshells," or *Brachiopods*, represent in themselves the fulness of a life that crowded the Silurian seas, so the two existing species of elephants with which we are familiar to-day, stand forth among quadrupeds as the representatives of a comparatively plentiful past population of these mammalian giants. The causes which have depopulated the earth of its elephantine tenants may be alluded to hereafter; but it is evident that neither size nor strength avails against the operation of those physical environments which so powerfully affect the ways and destinies of man and monad alike. One highly important feature of elephant organisation may, however, be noted even in these preliminary details respecting the modern scarcity of elephantine species, namely, that the slow increase of the race, and, as compared with other animals at least, the resulting paucity of numbers, must have had their own share as conditions affecting the existence of these huge animals. The elephants are, of all known animals, the slowest to increase in numbers. At the earliest, the female elephant does not become a parent until the age of thirty years, and only six young are capable of being produced during the parental period, which appears to cease at ninety years of age; the average duration of elephant life being presumed to be about a hundred years. But it is most interesting, as well as important in view of any speculation on the increase of species and on the question of competition amongst the races of animal life, to reflect that, given favourable conditions of existence, such as a sufficiency of food, a freedom from disease and from the attack of enemies—and the elephant race, slow of increase as it is, would come in a few thousand

years to stock the entire world with its huge representatives. On the data afforded by the foregoing details of the age at which these animals produce young, and of their parental period, it is easy to calculate that in from 740 to 750 years, 19,000,000 of elephants would remain to represent a natural population. If such a contingency awaits even a slowly increasing race such as the elephants unquestionably are, the powerful nature of the adverse conditions which have ousted their kith and kin from a place amongst living quadrupeds, can readily be conceived. In the face of such facts, the contention that the "struggle for existence," in lopping off the weak and allowing the strong to survive, accomplishes in its way an actual good, becomes clear. And the important biological lesson is also enforced, that there is a tolerably deep meed of philosophy involved in the Laureate's pertinent remark concerning the "secret meaning" of the deeds of Nature, through

> finding that of fifty seeds
> She often brings but one to bear.

Reference has already been made to the paucity of existing species of elephants, only two distinct species being included in the lists of modern naturalists. These are the African elephant (*Loxodon* [or *Elephas*] *Africanus*) and the Indian elephant (*Elephas Indicus*). But the elephantine race is not without its variations and digressions from the ordinary type. We discover that amongst the elephants of each species "varieties" are by no means uncommon. These varieties appear as the progeny of ordinary animals. Thus the Sumatran elephant and that of Ceylon are regarded as constituting a distinct species, one authority, Schlegel, indeed, affixing to it the distinctive appellation of *Elephas Sumatrensis*. The balance of zoological opinion, however, is in favour of the Ceylon form being simply a "variety" of the Indian species; in other words, the differences between these two forms are not accounted of sufficient merit to elevate the former to the rank of a distinct animal unit. The famous "white elephants," whose existence has given origin to the proverbial expression concerning the disadvantage of unwieldy possessions, have a veritable existence. In Siam, as is well known, these animals are regarded with the utmost reverence, and are held in sacred estimation and kept in royal state by sovereign command. They are to be regarded, however, merely as an *albino* or colourless "variety" of the Indian species. Their production depends, like that of albinos or white varieties of birds or other animals, on some undetermined conditions affecting development. We occasionally find white varieties of birds—even including that paradoxical anomaly, a white blackbird—and albino cats are as familiar objects as are albino rabbits and white mice. Darwin remarks on the fact that albinism is very susceptible of transmission to offspring, and it is so even in

the human race. It is not known whether the white elephants exhibit any special peculiarity of structure or life; but the interesting correlation has been observed, that almost all white cats which possess blue eyes are deaf. The nature and origin of this association of characters are unknown, but the occurrence of such apparently unconnected states serves to remind us that great as yet are the mysteries which environ the becoming of the living worlds.

The characters of the Indian and African elephants respectively, are by no means difficult to bear in mind. The Indian elephant (fig. 1, 1) has a concave or hollowed forehead, and the ears are of relatively moderate size. The eye is exceptionally small, whilst there are four nails or hoofs on the hind feet; the number of toes on each foot being five in all elephants. The colour of the Indian species is moreover a pale brown, and is of a lighter hue than that of the African species; and whilst the former has "tusks" in the males alone, the latter possesses tusks in both sexes. The African elephant (fig. 1, 2) has a rounded skull and a convex forehead, and the ears are of very large size. It possesses only three nails on the hind feet, and four hoofs on the front toes. Certain important differences, to be presently noted, also exist between the teeth of these species.

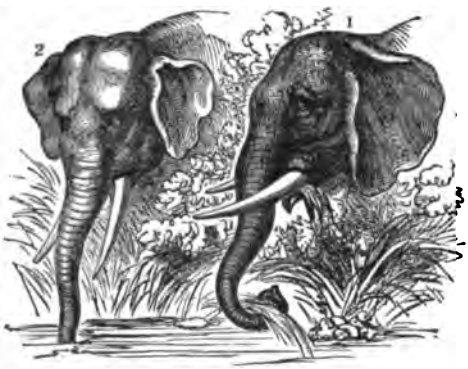

FIG. 1.—HEADS OF (1) AFRICAN AND (2) INDIAN ELEPHANTS.

The limits of size of the two species of elephants appear to have afforded subject-matter for considerable discussion. The average height of the male Indian elephant is from eight to ten feet, and that of the females from seven to eight feet. The African species, according to the most generally recorded testimony, attains a larger size than its Indian neighbour. Sir Emerson Tennent, quoting a source of error in the measurement of elephants, gives the remarks of a writer who says:—"Elephants were measured formerly, and even now, by natives, as to their height, by throwing a rope over them, the ends brought to the ground on each side, and half the length taken as the true height. Hence the origin of elephants fifteen and sixteen feet high. A rod held at right angles to the measuring rod, and parallel to the ground, will rarely give more than ten feet, the majority being under nine."

As regards the number of elephants captured annually, a recent return gives us 503 as captured in the three years ending 1880, in the forests of Assam, by the Indian Government.

There exist a few points in the special anatomy of the elephants of which it may be permissible to treat briefly, and of these points, the skeleton presents several for examination. First in interest, perhaps, comes the enormous size of the skull, and the modifications wherewith this huge mass of bone is rendered relatively light and more easily supported on the spine. The skull of the elephant is unquestionably large, even when considered in relation to the huge body of which it forms such an important part; but when the skull is seen in section, we discover that, instead of presenting us with a solid mass of bone, its walls are hollowed out in a remarkable fashion, so as to materially reduce its weight. In order to thoroughly understand how the elephant's skull is thus modified, it is necessary for a moment to refer to the structure of the ordinary quadruped cranium. It is a well-known fact that as the skull advances towards maturity, its bones undergo certain changes with the view of adapting themselves to the growth and protection of the brain and organs of sense. The increase of that part of the skull which forms the brain-case naturally takes a direction in which the thickness of the bones participates; but the adaptation of skull to brain is also wrought out through the development of certain "cells" or spaces—often also named *sinuses*—between the two layers or "tables" of which the bones consist. An example of such spaces in man is found in the so-called "frontal sinuses," which exist between the layers of the frontal or forehead bone, just above the nose. In other quadrupeds (*e.g.* dog) these spaces also exist, and they occur in other parts of the skull as well.

Now, it is by a huge and extreme modification of the "sinuses" of the skull that the elephant's cranium is rendered light and more easily borne. It is evident that a demand exists in these animals for a skull of great strength, which not only shall be equal to the task of giving origin to muscles of power sufficient for the animal's movements, but which may also adequately support the great "tusks." And Nature has succeeded accordingly, by a most interesting modification, in uniting size and strength to a minimum of weight. If we examine the skull of a young elephant, in the sixth month of its life, the skull-bones are well-nigh solid, and certainly present no trace of the curious alteration of which they ultimately become the subjects. But in the adult skull great spaces, corresponding to the "sinuses" of man and other animals, are seen to exist, these spaces in some cases actually separating the two layers of the skull-bones to an extent of twelve inches. Nor are these spaces limited to the frontal bones, for they exist in the upper jaw bones, and extend even to those forming the animal's palate; whilst the

spaces of the distinct bones are frequently seen to unite and thus to throw the cavities of these bones into one. Such a modification implies a far back adaptation of structure acting through countless generations of elephantine forms; and it is equally important to note that the essential features of such modification are to be found in other quadrupeds—that, in short, the peculiarities of elephantine skulls are not special and original creations, but merely modifications of the ordinary quadruped cranium.

A very short but strong neck, and powerful bony processes borne on the joints thereof, serve as support and holdfasts respectively for the huge cranium. In other parts of the skeleton, such as in the shape and form of the shoulder-blade, the elephants resemble the Rodent quadrupeds, such as the hares, rabbits, rats, beavers, &c.; and it has long been a notable fact of elephantine anatomy, that this resemblance is by no means limited even to the bones. But a somewhat ludicrous peculiarity of the elephants, readily noted by the observer, and one referred to by both classic and modern poets, is their awkward gait; and this again depends upon a readily understood anatomical modification. It is such a peculiarity that is referred to in "Troilus and Cressida," in the lines—

> The elephant hath joints, but none for courtesy.
> His legs are legs for necessity, not for flexure.

And again, the phrase—

> I hope you are no elephant, you have joints,

evidently refers to the curious and ungainly movements of these quadrupeds. The explanation of the elephantine gait rests primarily with the length of the thigh-bone, and with the facts that this bone is very long and lies perpendicularly to the line or axis of the spine; the thigh not forming an acute angle with the spine, as in other quadrupeds. Thus, the "ham" of the animal stretches half-way down the thigh, and when the animal walks the bend of the knee or leg at the latter point imparts a decided clumsiness to the gait. The great body rests, not so much upon the toes, as upon the great pads which unite the toes, and which in fact constitute a broad, flat sole behind these members. Similar pads in the rhinoceros and hippopotamus support the weight of the body. No collar-bones are developed in the elephant race; a fact which, of course, bears a relation to the absence of those movements, such as climbing, &c., in which these bones play an important part, as serving to fix the limb employed. The brain of the elephant reveals certain points of anatomical interest. For example, the lesser brain or "cerebellum" is not covered by the brain proper or "cerebrum;" but the surface of the latter is deeply convoluted or folded. The existence of deep brain-convolutions in man is believed to be associated with a high

measure of intellectual power, and the elephants do not seem to belie the statement, as applied to lower life, when their sagacity is taken into consideration. The proportion borne by the weight of the brain to that of the body has always formed an interesting topic of physiological nature. As a matter of fact, great variations exist when the ratio of brain to body is examined in different animals. Thus in man, as is the case with lower animals, the ratio diminishes with increasing weight and height. In lean persons the ratio is often as 1 : 22 to 27, and in stout persons as 1 : 50 to 100. In the Greenland whale the ratio is given as 1 to 3,000; in the ox as 1 to 160; in the horse as 1 to 400; in the dog as 1 to 305; in the elephant as 1 to 500; in the chimpanzee as 1 to 50, and in man as 1 to 36.

The absolute weight of brain in an elephant which was seven and a half feet high, and eight and a half feet in length from forehead to tail, was 9 lbs. The brain of an Indian elephant was found to weigh 10 lbs.; and Sir Astley Cooper gives the weight of the brain of another specimen as 8 lbs. 1 oz. 2 grs., whilst that of an African elephant seventeen years old was found by Perrault to weigh 9 lbs.

The muscular system of the elephant necessarily partakes of the massive character adapted for the work of moving and transporting the huge frame. But the anatomy of the "proboscis" or "trunk" constitutes in itself a special topic of interest, and one, moreover, which gives to the proboscidian race one of its most notable characteristics. The "trunk" is, of course, the elongated nose of the elephant. It is perforated by the nostrils which open at its tip, and above the apertures is a curious finger-like process, which, when opposed to a small projection somewhat resembling a thumb in function, constitutes a veritable hand, and is utilised by the animal in almost every detail of its life. With the exception of the snout of the tapirs, the trunk of the elephant has not even a distant parallel in the animal series. Its muscles form two sets of fibres, one set of which compressing its substance also extends its length, whilst the second set shortens the organ and enables it to bend freely in any direction. When we add to the possession of this extreme muscularity, a high degree of sensitiveness, the

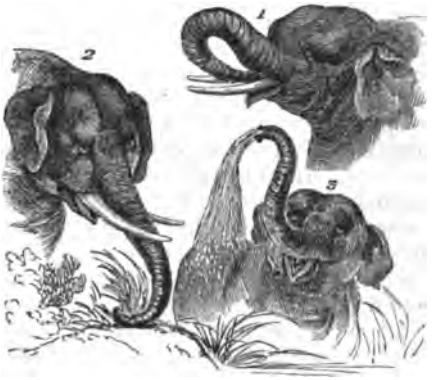

FIG. 2.—VARIOUS USES OF THE PROBOSCIS.

proboscis of these animals may be regarded in the light of one of the most useful as well as most interesting features of their organisation. Its use is not limited to the prehension of food (fig. 2, 1, 2), however, or even to the additional function of an organ of touch. Occasionally, water is drawn up into the trunk, and is then squirted over the body as from a flexible hose (fig. 2, 3), thus serving as a kind of shower-bath apparatus; and stories have been recorded wherein such a use of the proboscis has played a prominent part in the act of elephantine revenge on some over-bold or offending human.

The teeth of the elephantine race, as already remarked, form a highly characteristic feature of their anatomy. In the mouth of a higher quadruped, such as man, the bat, or ape, no less than four kinds of teeth are represented. These are the front teeth or incisors, the "eye-teeth" or canines, the premolars, and the molars or "grinders." Furthermore, the growth of any individual tooth of ordinary kind is of limited extent. As the roots of the "milk-teeth" disappear by a natural process of absorption, and as these teeth fall out to make room for their permanent successors of the second set, so the latter teeth in their turn, when old age creeps upon us, fall out by the decay and disappearance of their roots. Thus the growth of a tooth, like that of the body at large, is confined to a certain period, and by no means extends throughout the entire life of the individual. But there are other teeth in the animal world which do not so terminate their growth. The latter teeth continue to grow throughout the entire life of their possessors. They spring from what is known as a "permanent pulp;" a structure which, devoted to the original formation of the tooth, continues to add to its substance as long as life lasts. In the Rodent animals, such as the rats, mice, beavers, porcupines, squirrels, and their allies, the front teeth grow from "permanent pulps," the action of which supplies the loss of tooth-substance which results from the inevitable tear and wear incurred in the act of gnawing. So, also, in the walrus, the upper "eye-teeth" grow from "permanent pulps," and develop into the well-known ivory tusks of that animal; and although the prominent "eye-teeth" of the pigs do not increase throughout life, they yet exhibit a structure nearly approaching the persistent type of tooth-growth.

In the elephants, only two kinds of teeth are represented, these being the incisors or front teeth, and the molars or grinders; whilst the front teeth themselves only exist in the upper jaw. The incisors grow from "permanent pulps," and hence they increase during the whole life of the animal, or nearly so. A large pair of tusks may weigh from 150 to 200 lbs., and as regards structure they are found to consist of dentine or "ivory" and of "cement;" whilst the enamel, which forms such a characteristic feature of ordinary teeth, may or may not be represented. The tusks vary, according to Darwin, "in

the different species or races according to sex, nearly as do the horn. of ruminants. In India and Malacca, the males alone are provided with well-developed tusks. The elephant of Ceylon," adds Mr. Darwin, "is considered by most naturalists as a distinct race; there, 'not one in a hundred is found with tusks, the few that possess them being exclusively males.' The African elephant is undoubtedly distinct, and the female has large well-developed tusks, though not so large as those of the male." The molars or grinding teeth exhibit an equally curious structure. In the lifetime of an elephant twenty-four molar teeth are developed in all; six on each side of each jaw. But at any one time in the life of the animal, not more than two of these teeth are to be seen in each side of the jaw. A curious succession of these molars takes place in the elephants; for they are found to move from behind forwards; the teeth in use being gradually ousted from their place by their successors, as the former are worn away Thus the whole set of molars in due time moves forwards in the jaw, and each successive tooth is, as a rule, larger than its predecessor. In structure, the molars of the elephant are highly peculiar, each exhibiting the appearance rather of a compound than of a single tooth. Each tooth is built up of a series of plates set perpendicularly in the tooth, and consisting of ivory or "dentine" covered by enamel, whilst "cement" fills up the interspaces between the plates. As the tooth wears in its work, the enamel comes to project above the surface of the tooth, and a characteristic pattern is thus developed on the surface of the molars of each species of living elephant. Thus, in the Indian elephant, the molars exhibit a series of cross ridges, which are more numerous than those of the African species; whilst in the latter form, the enamel plates form a distinctly lozenge-shaped pattern. It sometimes happens that in elephants kept in captivity the succession of the teeth is disarranged, from the fact that the molars are not worn away fast enough, and the succeeding teeth are displaced, thereby causing deformity of the jaws.

The elephants were included in the older systems of classification in a somewhat heterogeneous group of quadrupeds named the *Pachydermata*. That this order—now abolished and divided to form several new groups—was motley enough in its representation, is readily seen, when we discover that the rhinoceroses, hippopotami, and other forms were included within its limits along with the elephants themselves. The technical name "Pachydermata" related to the thick skin which invests the bodies of the animals just mentioned, and in the elephants this characteristic is, of course, extremely well represented. The thick skin hangs in folds on the body, whilst the typical hair-covering which by natural right all quadrupeds possess is but sparsely developed. It would seem, however, that the young elephant possesses a much more profuse covering of hairs than the adult. Such a statement is

consistent with the general biological law which holds that the young form exhibits the primitive characters of the race more typically than the adult. In this view of matters, the young elephant is nearer the type of its ancestors than the adult; and in the young whales the same remark holds good; since the youthful cetaceans may possess a sparse covering of hairs such as the adults do not exhibit.

Speaking of the comparative hairlessness of the elephant and rhinoceros, Mr. Darwin remarks that, "as certain extinct species (*e.g.* mammoth) which formerly lived under an Arctic climate, were covered with hair, it would almost appear as if the existing species of both genera had lost their hairy covering from exposure to heat. This appears the more probable, as the elephants in India which live on elevated and cool districts are more hairy than those on the lowlands."

The social history and psychology of the elephant race form of themselves topics wide enough to fill a volume. From the earliest times, these animals have been enlisted by man in the service of war, or as beasts of burden, as aids in the chase, or even in the brutal and demoralising sports of the ancient arena. The value of ivory in the earliest ages must have given rise to elephant-hunting as a source of gain and profit; and the inroads of man upon the species have naturally caused not merely a limitation in the numbers of these animals, but have likewise served to modify in a very marked fashion their geographical distribution. But the utility of these great animals to man, depends as much upon their docility and tractable nature, as upon their manufacture of ivory. Probably there is no more sagacious animal than a well-trained elephant, and the development of such high instincts as these animals exhibit, may form an additional illustration of the marked influence of association with man in inducing the growth of intelligence and reasoning powers in the animal creation. No one may doubt that the dog, for instance, has benefited to a marked degree from such association with human surroundings; and that the comparatively low mental powers of many other animals are susceptible of higher development through domestication, is an idea fully supported by all that is known of instances where a wild race, or individual animal of wild habits, has been brought in contact with man. The "learned pigs" and tame hares, are cases in point; and the relatively low mental powers of many of the apes may be largely attributed to that want of interest in "poor relations" with which humanity, as a body, views the quadrumanous tribes.

The records of popular natural history teem with examples of the sagacity of elephants; a mental quality which, it may be added, is likely to owe much to the relatively long life, and corresponding opportunities of acquiring experience, which these animals possess: whilst it has been also remarked, that as the elephant, unlike the dog,

rarely breeds in captivity, and as each individual elephant has to acquire, independently of heredity, its own knowledge of the world and of man, so to speak, these great animals present infinitely more remarkable examples of animal sagacity than the dog. One specially interesting feature of elephant life consists in the aid given by the domesticated elephant to man in the capture of the wild species. The fact of these animals entering into an offensive and, from its very nature, an intelligent alliance with man against their own race, may be regarded either as illustrating the desire to benefit the race by conferring upon them the blessings of civilised life and employment, or as exemplifying a process of demoralisation and treacherous development which might afford an argument against the universally beneficial effects of domestication upon the animal form. Nor is the problem rendered any the less attractive to the metaphysician and moralist, when it is discovered that it is through the caresses and blandishments of the false females that the wild elephants are tempted into the snare: the parallelism betwixt the experiences of lower and higher life being too obvious in this instance to escape remark.

Probably no animal exhibits a greater knowledge or instinctive apprehension of danger than an elephant. Instances are numerous, for example, where an elephant has refused to cross a bridge esteemed safe by his human guides, but which has collapsed with the animal's weight, when, goaded and tortured to proceed, he has advanced in despair, only to find himself immersed in the water below. But cases are also recorded in which the danger experienced by the elephant itself has apparently not rendered it insensible to the safety of its keeper. "The elephant," says Darwin, "is very faithful to his driver or keeper, and probably considers him as the leader of the herd. Dr. Hooker informs me that an elephant which he was riding in India, became so deeply bogged that he remained stuck fast until the next day, when he was extricated by men with ropes. Under such circumstances elephants will seize with their trunks any object, dead or alive, to place under their knees to prevent their sinking deeper in the mud; and the driver was dreadfully afraid lest the animal should have seized Dr. Hooker and crushed him to death. But the driver himself, as Dr. Hooker was assured, ran no risk. This forbearance under an emergency so dreadful for a heavy animal, is a wonderful proof of noble fidelity." Swainson gives a description of the sagacity of an elephant under such circumstances, which is worth quoting in the present instance. "The cylindrical form of an elephant's leg—which is nearly of equal thickness—causes the animal to sink very deep in heavy ground, especially in the muddy banks of small rivers. When thus situated, the animal will endeavour to lie on his side, so as to avoid sinking deeper; and, for this purpose, will avail himself of every means to obtain relief. The usual mode

of extricating him is much the same as when he is pitted; that is, by supplying him liberally with straw, boughs, grass, &c.; these materials being thrown to the distressed animal, he forces them down with his trunk, till they are lodged under his fore-feet in sufficient quantity to resist his pressure. Having thus formed a sufficient basis for exertion, the sagacious animal next proceeds to thrust other bundles under his belly, and as far back under his flanks as he can reach; when such a basis is formed as may be, in his mind, proper to proceed upon, he throws his whole weight forwards, and gets his hind feet gradually upon the straw, &c. Being once confirmed on a solid footing, he will next place the succeeding bundles before him, pressing them well with his trunk, so as to form a causeway by which to reach the firm ground. . . . He will not bear any weight, definitely, until, by trial both with his trunk and the next foot that is to be planted, he has completely satisfied himself of the firmness of the ground he is to tread upon. . . . The anxiety of the animal when bemired, forms a strong contrast with the pleasure he so strongly evinces on arriving at *terra firma*." Such an account becomes extremely interesting, as convincing us that much, if not all, of the sagacity which is called forth by such circumstances, must be inherent and original, as opposed to that gained by experience. It cannot be supposed that the accident described can form such a frequent experience of elephant-existence in a wild state, as to constitute a certain basis for acquired knowledge of what to do in the exigency. On the contrary, it seems more reasonable to suppose that the inherent and intuitive sagacity of the animal is simply called forth by the threatened danger, and that such an exigency brings into play mental acts analogous to those whereby, through mechanical and similar contrivances to those employed by the elephant, man might rescue himself or his property from immersion in the swamps.

The memory of elephants is of highly remarkable nature, both as to its duration, and in its operation as enabling the animal to recognise friends and foes. I am fortunate in being able to place on record an instance of elephant memory of very interesting kind, and one which serves to show in a highly typical manner the remembrance by these animals of kindness, and also of the reverse treatment. In 1874, Wombwell's menagerie visited Tenbury in Gloucestershire, and on that occasion the female elephant, "Lizzie" by name, drank a large quantity of cold water when heated after a long walk; the animal, as a consequence, being attacked with severe internal spasms. A local chemist, a Mr. Turley, being called in as medical adviser, succeeded in relieving the elephant's pain, the treatment including the application of a very large blister to the side. The menagerie in due course went its way, but in May 1879, it again visited Tenbury, and as Mr. Turley stood at his shop door watching the zoological

procession pass down the street, the elephant stepped out of the ranks, crossed from one side of the street to the other, and having advanced to Mr. Turley, placed her trunk round his hand, and held it firmly, at the same time making, as Mr. Turley informs me, a peculiar grunting noise, as if by way of welcome. Thus it was clear that after an interval of five years, "Lizzie" had recognised an old friend in Mr. Turley, and that, moreover, she remembered him with a sense of gratitude for his successful endeavours to relieve the pain from which she had suffered. At night, Mr. Turley visited the menagerie, when the elephant again made every demonstration of joy, and embraced him with her trunk. She drew Mr. Turley's attention particularly to the side whereon the blister had been applied, thus showing that all the circumstances of five years previous were fresh in her memory. Observing that in 1881 the menagerie had again visited Tenbury, I wrote to Mr. Turley inquiring if "Lizzie" had again recognised her old friend. That gentleman replied, his letter bearing date May 1881, that she had again recognised him, beginning to "trumpet" whenever she beheld Mr. Turley amongst the spectators in the menagerie. On his speaking to his patient, she placed her trunk round his legs and lifted him from the ground, but in the gentlest manner possible. On Mr. Turley proceeding to examine one of her hind-legs which had been under treatment, the elephant kept holding one of her fore-legs towards him in such a fashion as to draw his attention to the limb. As Mr. Turley, however, had had no concern with the fore-leg, he was puzzled to account for the animal's movement; but the keeper explained that the fore-leg in question had been treated by a veterinary surgeon for an injury, and that the latter had used his lancet to afford relief. The elephant was irritated by the operation, and expressed her resentment on again seeing the veterinary practitioner by striking at him with her trunk. The act of calling Mr. Turley's attention to the fore-leg was simply an expression of admiration for the gentler treatment to which he had subjected his patient; the quieter medical treatment contrasting apparently with the rougher surgical measure to which the fore-leg had been subjected. It is thus clear not merely that the elephantine nature is endowed with an active memory, but that a lively sense of gratitude for past kindness is also represented in the list of mental attributes of this giant race.

A parallel instance of elephant memory is afforded by the case of an elephant which, having broken loose from the stables on a stormy night, escaped into the jungles. Four years thereafter, when a drove of wild elephants was captured in the "keddah" or enclosure, the keeper of the lost elephant went to inspect the new arrivals, and climbed on the railings of the "keddah" to obtain a satisfactory view of the captured animals. Having fancied that amongst the

animals he recognised the escaped elephant—an idea ridiculed by his comrades—he called his lost charge by its name. The animal at once came close to the barrier, and on the keeper proceeding into the enclosure and commanding it to lie down, the elephant obeyed, and the man led his former charge triumphantly forth from amongst its wild companions. But the memory of kindnesses is equalled in the elephant by that which recalls acts of injury to remembrance. The well-known story of the Indian elephant which, on being pricked by a native tailor near whose stall it had wandered, returned and deluged the man with a shower-bath of dirty water, finds many parallels in the history of elephant character. An elephant which was kept at Versailles by Louis XIV., was in the habit of revenging himself for affronts and injuries. A man who, feigning to throw something into his mouth, disappointed him, was beaten to the ground with the trunk and trampled upon. On a painter desiring to sketch this elephant with trunk erect and mouth open, his servant was instructed to feed the elephant for the purpose of inducing the animal to assume the desired attitude. But the supply of food falling short and elephantine chagrin being aroused, the elephant drawing up water into his trunk, coolly showered it down upon the unfortunate painter and his sketch, drenching the one, and rendering the other useless.

The pugnacity of the elephant is very great, and the determination with which contests are carried on between these animals is highly remarkable. Mr. Darwin, on the authority of the late Dr. Falconer, tells us that the Indian species fights in varied fashions, determined by the position and curvature of his tusks. "When they are directed forwards and upwards, he is able to fling a tiger to a great distance—it is said to even thirty feet; when they are short and turned downwards, he endeavours suddenly to pin the tiger to the ground, and, in consequence, is dangerous to the rider, who is liable to be jerked off the howdah"—for it is on

Elephants endors'd with towers,

as Milton has it, that the great carnivore of India is hunted.

A most remarkable trait of elephant existence, and one which parallels the proverbial "red rag" and bovine fury, is the apparent animosity of the race to white colour. Sir Samuel Baker says that both the African elephant and the rhinoceros attack grey or white horses with fury. The explanation of such traits of character probably lies hidden in that philosophy of colour in relation to sex and animal development which the researches of Darwin and others have so far unravelled.

As a final observation regarding the psychology of the elephant, Mr. Darwin's statements concerning the "weeping" of these animals

may be quoted. Remarking that the Indian species is known to weep, Mr. Darwin quotes Sir Emerson Tennent, who says that some "lay motionless on the ground, with no other indication of suffering than the tears which suffused their eyes and flowed incessantly." Another elephant, "when overpowered and made fast," exhibited great grief; "his violence sank to utter prostration, and he lay on the ground, uttering choking cries, with tears trickling down his cheeks." "In the Zoological Gardens," says Darwin, "the keeper of the Indian elephants positively asserts that he has several times seen tears rolling down the face of the old female when distressed by the removal of the young one." Mr. Darwin also makes the interesting observation that when the Indian elephant "trumpets," the orbicular muscles of the eyes contract: whilst in the "trumpeting" of the African species these muscles do not act. Hence, as Mr. Darwin believes that in man the violent contraction of the muscles round the eyes is connected with the flow of tears, it would seem by analogy to be a legitimate inference that the Indian elephant has attained a higher stage in the expression of its emotions than its African neighbour.

The social history of the elephants includes several somewhat melancholy incidents connected with the despatch of these animals, rendered necessary from their dangerous condition. The best known of these incidents is that connected with the death of Chunee, the Exeter Change elephant, reported in the "Times" for March 2, 1826. The account of the death of Chunee is as follows:—"The elephant was a male, and had been an inmate of the Exeter Change Menagerie for seventeen years. He was brought from Bombay, where he was caught when quite young, and was supposed to be about five years old when purchased by Mr. Cross; consequently his present age is twenty-two. The effect of his unavoidable seclusion had displayed itself in strong symptoms of irritability during a certain season from the first, and these symptoms had been observed to become stronger during each succeeding year as it advanced toward maturity. The animal was altogether kept at this season very low, and also plentifully physicked, for which latter purpose no less than one hundredweight of salts was frequently given to him at a time. Notwithstanding these precautions, the animal within the last few days had shown strong proofs of irritability, refusing the caress of his keepers and attempting to strike at them with his trunk on their approaching him, also at times rolling himself about his den and forcibly battering its sides. About 1 P.M. he became more ungovernable than ever, and commenced battering the bars of his den with his trunk. These bars are upwards of three feet in girth, and are composed of oak, strongly bound on all sides with iron, and are placed about a foot asunder. For some time they

resisted the ponderous blows which he almost incessantly directed against them, but by 2 P.M. one of them was found to be started from the massive cross beam into which it was mortised; and as at that time the animal still continued as violent as ever, serious fear began to be entertained lest he should break out, in which event the amount of damage or loss of life which he might occasion would have been incalculable. In these circumstances, although the value of the animal was at least 1,000*l.*, Mr. Cross at once determined on having him destroyed, and after some consideration it was resolved to give him some corrosive sublimate in a mess of hay. However, the animal no sooner smelt the mixture than he rejected it, and it was then determined to shoot him. Accordingly a messenger was sent to Somerset House, where two soldiers were on guard, who, on a suitable representation being made, were allowed to go over to the menagerie, taking with them their muskets. Several rifle guns were also obtained from different places in the neighbourhood and put into the hands of such of the persons about the establishment as had courage enough to remain in the room. In this manner, in all about fourteen persons were armed, but before commencing operations it was deemed prudent to secure the front of the den, by passing cords around those bars against which the animal's violence had been principally directed. This having been done and the muskets loaded, about a third of the party advanced to the front of the den till within about five yards of the animal and discharged their pieces at the tender part of the neck below the ear, and then immediately retreated to a recess at the lower end of the room for the purpose of reloading. The animal on finding himself wounded uttered a loud and piercing groan, and advancing to the front of the den struck his trunk several times with all his fury against the bars, another of which he succeeded in forcing out of its place. Having thus exhausted his fury, he became quiet, upon which another detachment of the party approached his den, and after firing upon him, retired into the recess as before; the animal on receiving the fire plunged again most violently against the front of the den, the door of which he actually lifted from off its uppermost hinges, but was prevented from getting out by the strong manner in which the ropes bound the different bars together. On his becoming more tranquil, preparations were made for firing a third volley; but no sooner were the muskets about to be levelled, than the animal, as if conscious of their being the cause of his wounds and also of the vulnerable parts against which they were intended to be directed, turned sharp round and retreated into the back of the den and hid his head between his shoulders. It hence became necessary to rouse him by pricking him with spears, which being effected, the muskets were discharged at him, and although several balls evidently took effect in the neck on this as well as on the

former occasion, still he did not exhibit any signs of weakness, beyond abstaining from those violent efforts which he had previously made against the front of his den; indeed, from this time he kept almost entirely at the back of his den, and although blood flowed profusely from the wounds he had received, he gave no other symptoms of passion or pain than an occasional groan. For about an hour and a half in this manner a continuous discharge of musketry was kept up against him, and no less than 152 bullets were expended before he fell to the ground, where he lay nearly motionless, and was soon despatched with a sword, which, after being secured upon the end of a rifle, was plunged into his neck. The quantity of blood that flowed was very considerable, and flooded the den to a great depth. This was the same elephant who was the *accidental* cause of its keeper's death, whose ribs it crushed four months back while in the act of turning round in its den."

After reading this account, we may well feel tempted to endorse the opinion of a correspondent of "Land and Water" who remarks that the like of it "can never occur again, thank God, in England."

The history of the elephants would be manifestly imperfect, even when detailed in the briefest manner, without a reference to their present distribution and to the biography of the race in the past. As in the case of many other groups of animals and plants, we can only fully appreciate the modern relations of the elephants when some knowledge of their development in the geological ages has been obtained. In the eyes of the modern naturalist, the present of any living being is not merely bound up in its past development, but the existing conditions of any race become explicable in many cases only when the former range of the group in time has been ascertained. This holds especially true of the elephants; for the existing species represent the remnants of a once larger and far more extensive distribution of proboscidian life. Hence it behoves us to make the acquaintance, firstly, of their present distribution, and secondly of their distribution and development in past ages, if we are to understand with any degree of completeness and mental satisfaction the relations of the elephantine races.

The distribution of the elephants on the earth as it now exists may be disposed of in a very few words. The Indian species occurs in Asia, from the Himalayas to Ceylon, whilst its range extends eastwards to the Chinese borders, and southwards to Sumatra and Borneo as well. The African species possesses as localised a habitat. It was Swift who, remarking on the customs of geographers in his day, said,

> So geographers in Afric maps
> With savage pictures fill their gaps,
> And o'er unhabitable downs
> Place elephants for want of towns.

The witty Dean's lines show at least that the geographers did not mistake the wide distribution of the giant animal in the Ethiopian continent. For, south of the Sahara—the territory north of which is zoologically a part of Europe—the African elephant is widely found, forming one of the most characteristic features at once of the African landscape and of the Ethiopian fauna, and dividing the sovereignty of the land with the lion himself.

Turning now to the past history of the elephant race, one may primarily note the more prominent members of the group which rank amongst the curiosities of the geologist. First in order comes the extinct Mammoth—the *Elephas primigenius* (fig. 3) of the naturalist. Of this huge elephant we possess a considerable knowledge, inasmuch as specimens have been obtained, literally packed amid the Siberian ice, and so perfectly preserved that even the delicate tissues of the eyes could be inspected. This was the case in the famous specimen found in the frozen soil of a cliff at the mouth of the Lena in 1799. The skin of this huge elephant was then seen to be clothed with a thick coating of reddish wool interspersed with black hairs. The skeleton, removed in 1806 by Mr. Adams, and preserved in St. Petersburg, measures 16 feet 4 inches in length, the height is 9 feet 4 inches, and the tusks measure each 9 feet 6 inches along their curve. The mammoth's tusks appear to have had a wider curvature (fig. 3) than those of existing elephants; and probably, like the African species, both male and female mammoths possessed these great teeth. The measurement of mammoth tusks from recent deposits in Essex gives a length of 9 feet 10 inches along the outer curve, and 2 feet 5 inches in circumference at the thickest part. Another specimen weighed 160 lbs.; and a dredged specimen taken off Dungeness was 11 feet long. The mammoth's tusks have long formed articles of commerce and barter in Siberia; the ivory, as Professor Owen remarks, being "so little altered, as to be fit for the purposes of manufacture." The mammoth's extensive range forms not the least noteworthy point in its history. It certainly roamed farther abroad, so far as we know, than any other elephantine form. Its remains occur in Britain and in Europe generally; they have

FIG. 3.—SKELETON OF MAMMOTH.

been found on the Mediterranean coast and in Siberia; and they are met with in North America as well. In Scotland and in Ireland the mammoth was apparently less plentiful, but its remains occur in these countries, where, indeed, no other elephantine remains are found. It may be added, that the molar teeth of the mammoth are by no means unlike those of the Indian elephant in the arrangement and pattern of its enamel plates.

Another extinct elephant, equally famous with the mammoth, was the *Mastodon*—a name given to these animals in allusion to the nipple-like projections seen on the surface of the molar teeth. Their remains occur in Europe, Asia, and in North and South America. In the morasses of Ohio and Kentucky, for example, whole skeletons of these interesting elephants have been discovered. The length of the mastodon in some cases exceeded 16 feet; and the tusks have been found to measure 12 feet in length. Over a dozen species of mastodons have been described, but they agree in certain important characters which serve to distinguish them from other elephants. Thus, the roughened teeth appear to have been adapted for bruising coarse herbs and leaves—indeed, associated with mastodon remains in America, collections of leaves have been found occupying the situation in which the stomach of the animal would have been situated, and thus indicating the dietary of these extinct giants. Furthermore, a most important difference between the mastodons and other elephants is found in the fact that these animals possessed two tusks springing from the lower jaw, in addition to the tusks with which, as in ordinary elephants, the upper jaw was provided. But it would seem that these lower tusks never attained a large size, whilst it is probable that they fell out when the animal attained the adult period of its existence.

More extraordinary still, in respect of its variations from the ordinary structure of the elephants, was the *Deinotherium* (fig. 4), the fossil remains of which occur in Europe and in India. The skull of a deinotherium has been found to measure 4 feet in length, whilst a thigh-bone was 5 feet 3 inches long. Thus, in so far as size is concerned, the deinotherium may claim a foremost place amongst its elephantine cousins. But various circumstances seem to suggest that the latter animal departed from the elephant type in certain

FIG. 4.—RESTORATION OF DEINOTHERIUM.

important particulars, whilst some authorities have been even found to suggest that it represents a connecting link between the elephants and the sea-cow or manatee order (*Sirenia*). The tusks of the deinotherium spring from the lower jaw (fig. 4); and instead of being curved forwards and upwards, they bend abruptly downwards and backwards. The use of these tusks is extremely difficult to determine, but it has been suggested that the deinotherium was an aquatic animal, living in shallow waters, and that these huge teeth may have enabled it to root up the plants on which it fed, or have enabled it to climb, as does the living walrus, from the sea on to the river banks.

In addition to these latter elephants, which are essentially distinct from the living species, certain extinct forms may be mentioned which, in their essential characteristics, resembled existing proboscidians more or less closely. Thus, we know that elephants closely related to the Indian species, existed in Asia in Miocene times, the remains of at least six species being obtained from Indian deposits of that age; and we also know that Europe boasted of elephants in that period of geology known as the "Pliocene;" for in the deposits of France and Italy, as well as in the formations of that age in Britain, elephant remains occur. Later in point of time come the curious "pigmy elephants" of Malta, whose remains exist in that island, and whereof one (*Elephas Melitensis*) attained the size of a donkey, whilst another (*Elephas Falconeri*) was smaller still, and averaged 2½ or 3 feet in height.

The geological order and the succession in time of these various elephants is important to trace; for the unravelling of so much of the past history of the elephants as is known to us depends upon the knowledge of their succession and of the periods of their appearance and extinction. If we tabulate the rocks wherewith the past of the elephants is concerned, we may render their arrangement clear thus:—

TERTIARY ROCKS including	QUATERNARY	Recent (Soils, &c.) Post-Pliocene (Ice Age).
	PLIOCENE	
	MIOCENE	
	EOCENE	

Thus the oldest and lowest of the Tertiary rocks—which are themselves collectively the most recently formed—is the "Eocene," and the succeeding "Miocene," "Pliocene," and "Quaternary," are given in their due order; the latter formations bringing us to the soils and surface accumulations of our own day. The "Ice Age," or "Glacial Epoch," we may also note, occurred during the Post-Pliocene period, as shown above.

Turning now to the past history of the elephants, we find the first chapter of that biography to open in the "Miocene" age. The

earlier or "Eocene" period contains no elephant fossils, and it may have been that in this Eocene age, which beheld the first beginnings of nearly all the existing quadruped races, the evolution of the elephant stock from its ancestry was taking place. Leaving for the present the consideration of the probable root of the elephantine tree, we thus discover in the Miocene period the first beginnings of elephant existence. In this period the mastodons roamed over Europe and India, whilst in this age also the deinotheriums, with their great lower tusks, made their first appearance on the stage of time. As the geological series progressed, and as the Pliocene age succeeded the Miocene times, we discover the elephants in increasing numbers. The Miocene, with its relatively few elephantine forms, contrasts forcibly with the increase of those animals in the succeeding age. Europe and India harbour its Pliocene elephants, as we have seen; whilst both Europe and America in this latter age possessed the mastodons. The Post-Pliocene period, however, dawns in turn, to find the mastodons still existent in North America, but unknown in Europe; whilst the mammoth now appears as a representative form, along with survivals of the European elephants of the Pliocene time. The "pigmy elephants" of Malta also belong to the Post-Pliocene age.

It is, therefore, tolerably clear that a distinct *succession of types* of elephantine forms has appeared on the earth's surface, beginning with elephants which, like the deinotherium and mastodon, differ from existent species, and ending with elephants which, like the mammoth or the European elephants of the Pliocene, more or less closely resembled the quadruped giants of to-day. It becomes interesting, further, to trace out the later history of the race before the bearings of these facts on the origin of the elephant race are discussed. The mammoth, for example, certainly survived the "ice age," to the irruption of which was probably due the extinction of the other elephantine forms. We know of this survival because its remains occur in "recent" or "post-glacial" deposits. We are also certain that early man must have beheld the mammoth as a living, breathing reality, for its remains have been found associated with the rude implements of early men, and a rough portrait of the great red-haired elephant has been discovered, scratched on one of its tusks—a rude but unquestionable tribute of early art to the science of zoology. Its woolly hair, protecting it against the rigours of the ice age, may have enabled it to survive that period, which was apparently so fatal to elephant life at large.

Summing up the details we have thus collated, from the geological side, we may now face the problem of the origin of the elephant race. Not that the problem itself is fully answerable, for our knowledge of the elephant race in the past is yet of comparatively limited

extent; but the main lines of the biological argument are clear enough to those who will consider, even casually, the evidence already at hand. It is thus probable that the true elephants, which belong to the Pliocene period, were ushered into existence, so to speak, by forms that are less typical elephants—mastodon and deinotherium —when judged by the standard of existent elephantine structure. There are various species of mastodons known to geologists, which exhibit a gradation in the matter of their teeth, and presumably in other structural aspects as well, towards the ordinary elephant type. As the mastodons precede the ordinary elephants in time, we shall not be deducing an unwarrantable inference if we maintain that the origin of the true elephants, both fossil and living forms, may safely be regarded as arising from the mastodon stock. The elephants of to-day are connected by links of obvious nature with the Pliocene and Post-Pliocene forms; and when the "ice age" cleared the earth of the vast majority of the species, the progenitors of our living elephants must have escaped destruction and have survived the cold, possibly in the regions wherein they now exist, just as the mammoth, in its turn, survived the rigours of the ice period, through the presence of its woolly coating and its hardier constitution. There seems thus to be no special difficulty, either of purely geological or of intellectual nature, in conceiving that the elephants of to-day are simply survivals of that elephantine host, whose existence was well-nigh terminated by the ice age, and which left the mammoth, and the progenitors of our living elephants, to replenish the earth after a catastrophe as sweeping and fatal in its nature as any deluge.

But if the origin of the modern and later elephants may thus be accounted for, and if their geographical birthplace may be assumed to exist within the confines of the Old World, a more fundamental and anterior query may be put with reference to the origin of the mastodon stock, which we have supposed, and with reason, is the founder of the existing elephant races. From what stock, in other words, did the mastodons themselves arise? The chain of organic causation, to be perfect and complete, cannot assume the mysterious origin of the mastodon. That stock must, in its turn, have originated in an ancestry less like the elephants than itself. It is not improbable that the evolutionist of the future will seek and find the mastodon ancestry in the deinotherium group, or in some nearly related forms. For, as we have seen, the deinotherium exhibits a structure which appears to relate the elephants to other and lower quadrupeds, such as the sea-cows and their neighbours.

If this supposition be permissible, then a further stage still awaits our intellectual journey in the search after the origin of the elephant races. In the Eocene rocks of North America, occur the fossil remains of some extinct quadrupeds of which the *Dinoceras* is the

best known form. These animals unite in a singular fashion the characters of elephants and ordinary "hoofed" quadrupeds. Whilst they possessed horns, they also developed tusks from the eye-teeth; and from a survey of their complete organisation, Professor Marsh tells us that the position of these unique quadrupeds is intermediate between the elephants themselves and the great order to which the hoofed quadrupeds belong. Dinoceras and its neighbours precede the deinotherium and mastodon in time, and this fact alone is important as bearing on the assumed relationship of these forms.

It may thus at present be assumed with safety that the evolution of the elephants has taken place from some ancient Eocene quadruped stock, represented by the Dinoceras group, which belongs to no one group of living quadrupeds, but is intermediate in its nature, as we have already observed. From some such stock, then, we may figure the deinotherium and mastodon races to have been in due time evolved. The New World in this light must have been the birthplace of the elephant hosts; for the Dinoceras and its neighbours are of North American origin; migration to the Old World having taken place by continuous land-surface then existent, and the further evolution of the living species and their fossil neighbours having occurred in the Eastern Hemisphere. Thus once again we arrive at the existing races of elephants. These are simply the survivals of an ancient line of quadrupeds, whose history is simply that of every other living being—animal or plant—a history which, like the unfolding of a flower, leads us from form to form, along pathways of variation and change, and which, at last, as the ages are born and die, evolves from the buried and forgotten races of past monsters, the no less curious and unwieldy quadruped giants of to-day.

V.

THE PAST AND PRESENT OF THE CUTTLEFISHES.

FEW groups of the animal kingdom possess a greater interest, either for the zoologist or for the general investigator, than that selected as the subject of the present article. From the earliest ages in which human curiosity concerning external nature began to develop into scientific observation, the cuttlefishes have formed subject-matter of remark. In the writings of the classic naturalists they receive a due meed of attention. Their peculiarities of form and habits attracted the notice of Aristotle and Pliny; and even their development, in its more readily observed phases, was studied in the days when biology was but an infantile science. Tracing the lines of cuttlefish lore onwards through the centuries of growing culture, we discern the mediæval spirit of exaggeration and myth seizing upon the group as a likely subject for enlargement and discussion. In the fabulous history and "folklore" of zoology, the cuttlefishes have over and over again played a more than prominent part. In the days of their mythical history they have swallowed whole fleets of ships; they have been credited more than once with the destruction of even an armoured navy; and on more than one occasion there can be little doubt that they have played the parts of Sindbad's floating island, and of the "great unknown," the sea-serpent itself.

To the modern zoologist, however, eager in his search after the causes which have wrought out the existing order of animal nature, the cuttlefishes present themselves as an unusually interesting group. Regarded merely as to their structural details, there is no lack, but on the contrary an overflowing amount of instructive lore in their anatomical history. Their physiology is equally curious. The details of cuttlefish existence, from the consideration of their vital processes to that of their ordinary habits and outward mode of life, present a well-nigh endless variety of curious facts and unusual features. The establishment of aquaria has naturally led to the better acquaintance of the public with the cuttlefishes—or rather with certain members of this class, of which the octopus is the most notable example. Victor Hugo's "Toilers of the Sea" may possibly be credited with the first prominent introduction of the octopus to popular notice; indeed of the cuttlefish class it may be said, as was remarked of Byron himself, that one morning they awoke to find themselves ranked amongst the lions and celebrities of the day. It is sincerely to be

hoped that the interest evoked by the exhibition of the cuttlefishes "at home" will not be allowed to exhibit the ordinary and ephemeral fate of popular exhibitions, but that, on the contrary, the germs of a lasting interest in scientific study may be sown by the aquarium-movement at home and abroad. Not less interesting is the history of their distribution in existing seas, or their life in the oceans of the past as revealed by the study of their fossil remains. Their etiology or evolution—forming, in their case, as in that of every other group of organisms, the crowning question and focus of all scientific research—is, last of all, a part of their history that teems with special interest. Even if the materials for constructing the genealogy of the race are still of meagre amount; even if the pathways of cuttlefish descent in time past are often obscure, and sometimes completely hidden from the furthest gaze of modern biology; even if the lines of their development, as that phase of their personal history is traceable from the egg to-day, are frequently puzzling and indefinite, the evolution of the race according to the general principles of descent is yet an unquestioned fact. It is merely the exact lines and pathways of their progress in time which form matter of dispute; the fact of their evolution and progressive modification from pre-existing forms is never questioned by the modern biologist. Thus, on every hand, the group of the cuttlefishes may be said to be encompassed by circumstances which place them in the first rank of curious and in many respects abnormal forms. In this article we may endeavour to obtain a general, even if in many respects a brief and cursory, idea of the place in nature which these beings may be said to hold.

The zoological position of the cuttlefishes remains, in one sense, unaltered amidst the general revolution to which the classifications and arrangements of past decades of zoology have been subjected. Their position as the veritable aristocrats of the *Molluscan* sub-kingdom, or that including the familiar "shellfish" as its representative, was well defined by Linnæus himself. In that position the cuttlefishes still remain, although, indeed, the general constitution of the sub-kingdom in question has been widely altered. In bygone days, under the term "mollusc" were included such animals as the "sea-mats" or *Polyzoa*, the "sea-squirts" or tunicates, the *Brachiopods* or "lamp-shells;" and the ordinary groups of shellfish proper, such as the oysters, mussels, and their kin (*Lamellibranchiata*); the *Gasteropods* or whelk and snail group; the *Pteropods* or "sea-butterflies;" and finally the cuttlefishes, or *Cephalopoda* as they are technically named. From the Mollusca, the Polyzoa and Tunicata have been eliminated. The former now assert themselves as relatives of the worms; whilst the development of the sea-squirts has plainly betokened their relationship to lower vertebrates. The "lampshells," whilst of generally lower structure than the ordinary "shellfish" races, still retain their

position as "molluscs," and the Lamellibranchs, gasteropods, and cuttlefishes therefore remain in close structural and developmental relationship to represent the molluscan branch of the great genealogical tree of the animal world. It is most important, at the outset of our study, to bear clearly in mind the systematic position of the cuttlefishes in the series. Their apparently marked affinities in several respects with vertebrated animals might lead to the supposition that the cuttlefishes possessed a relationship with the highest type of animals. But, as we shall hereafter note, such likenesses are explicable on other grounds than that of a common origin. Standing at the far extremity of a "phylum" or branch of the animal series, the cuttlefishes possess neither structural nor other direct affinity with the vertebrates, whose root-stock, lying in the tunicate group, has but the remotest affinity with the beginnings of molluscan development. In a word, the Cephalopoda exist in that most natural classification of animals, which, as Darwin remarks, is the embryological or developmental, at the tip of one branch of the animal tree. The vertebrates, on the other hand, have developed along a different and widely divergent branch, whose lines of growth are in nowise parallel to, and attain a far higher rank than, those of the molluscan twig. The mere consideration of the relative position of the cuttlefishes in the series thus impresses the all-important truth, that the classification of living beings can in no sense be represented by the linear arrangement of former scientific periods. The constitution of both animal and plant worlds is not that of simple even growth in one direction; nor does each round of the ladder fall into its natural place as beneath a higher and above a lower group respectively. We cannot in nature begin with the monad, and advance by successive stages in a straight line through every known form, upwards and onwards, to man. The natural arrangement of animals or plants is that indicated by their development. The groups of living beings are the divergent branches of a tree; all of which branches have something in common with the parent stem, but present us with divergent lines of growth and with wide variations in the height or rank to which they attain.

The definition of the *Cephalopoda*, or cuttlefish class, is largely a matter of commonplace observation. Linnæus, naming them "cephalopods," or "head-footed" molluscs, indicated the structural feature which was calculated to appeal most plainly even to non-technical minds. The circlet of arms, feet, or tentacles crowning the head-extremity of a cuttlefish, thus presents us with a personal character of unmistakable nature. It is necessary, however, to bear in mind that the ordinary and to a certain extent natural fashion of representing a cuttlefish head upwards is, in zoological eyes, a complete reversion of its surfaces. To understand clearly why to speak of a

cuttlefish head as its *lower*, and of its tail as its *upper*, extremity, is a correct zoological designation, we must enter upon a comparison of the cuttlefish body with the forms of its neighbour molluscs. The contemplation of such a familiar being as a snail or whelk, introduces us to a characteristic example of molluscan form and anatomy. The head of the snail or other gasteropod is clearly enough defined; and no less plainly discernible is the enlarged and broadened surface on which the animal walks. This surface is known as the "foot." In one shape or another, this "foot" is a characteristic possession of the molluscan tribes. In a section of a mussel or cockle, we perceive the "foot" to exist as a muscular mass developed in the middle line of the body below, and variously used in the mussel-class as a spinning organ, a leaping pole, and a boring apparatus. Here we note the natural development of the foot in the middle line of the animal. Let us suppose this foot to be extended downwards, and to be broadened so as to form a surface of progression, and we may conceive readily of the modification whereby a simple foot like that of the mussel becomes developed to form the enlarged disc of the gasteropod. In the latter case, we observe that the foot occupies the floor of the body; the bulk of the body, and the head in particular, being borne above.

Cuttlefish development can be shown to run, so far, in parallel lines to those of the personal evolution of mussel and snail. But divergent paths soon appear in cuttlefish development; and these variations, whilst they indicate an ancient departure from the ordinary molluscan type, likewise give to the subjects of our present study their most characteristic features. When a mussel or snail is watched in its earlier stages of development, the embryo is seen, sooner or later, to produce an appendage highly characteristic of molluscan young at large, and named the *velum*. By aid of this ciliated fold, such an organism as a young cockle, for instance, swims freely through its native waters. This velum undergoes varied changes and alterations in the after stages of molluscan development; but when cuttlefish development is studied in its fullest details, no velum is found amongst the possessions of the larval body. Such an omission has naturally been made the subject of remark by naturalists. Some authorities—Grenacher, for instance—have insisted upon the recognition of the arms of the cuttlefish head as the representatives of the missing velum. But as the latter organ always exists on the dorsal or upper side of the mouth, and as the arms are placed originally behind and under the cuttlefish mouth, the correspondence of arms and velum has not been accepted by zoologists. On the other side stands out the opinion of Huxley, who regards the "arms" of the cuttlefish head as more truly corresponding with the "foot" of the mussel, snail, and other molluscs.

The margins of the foot, in this view of matters, have been prolonged in the young cuttlefish to form eight, ten, or more arms, and the front and sides of the foot, having overgrown the mouth, are united in front, so that the mouth appears to be placed in the centre of the foot, instead of in front and above it, as in other molluscs. So, also, most naturalists maintain, and with every appearance of correctness, that the characteristic "funnel" of the cuttlefishes—to be hereafter referred to—is an organ formed by two side processes of the foot, named *epipodia.* Adopting the view thus sanctioned by competent authority, we may trace in a cuttlefish the highly modified form of a snail or whelk, and the still more modified form of the mussel tribes. The foot, instead of growing backwards and downwards as in the snail, and thus forming a broad walking disc, comes to grow over the mouth in front. So that, placing a cuttlefish in structural comparison with a whelk or mussel, we should have to set it head downwards, when the foot (or arms) would be lowest, and the great bulk of the body, with the heart uppermost, would be situated, as in the snail, above the foot.

The group of the cuttlefishes may be said to divide itself in the most natural fashion into two main divisions. The first of these groups includes all living cuttlefishes save one—the pearly nautilus. This first division is that of the *Dibranchiates*, or two-gilled cuttlefishes. The familiar octopus (fig. 5), the loligos or squids, the sepias, and the argonauts or paper nautili, are amongst the best known of its representatives. The second group is represented by a single living cuttlefish, the pearly nautilus (*Nautilus Pompilius*), just mentioned, and by many fossil and extinct forms. These are the *Tetrabranchiates*, or four-gilled cephalopods, which, in respect of their general anatomy, their development in time, and their distribution in space, may be said to stand apart in the most marked fashion from the two-gilled cuttles which throng the seas of to-day. We shall dis-

FIG. 5.—CUTTLEFISH SWIMMING.

cover that the clues to the evolution of the cuttlefish race emerge in greater part from the fossil history of the four-gilled forms. But as the two-gilled members of the group constitute well-nigh its whole living population, the general nature of these animals may be most satisfactorily investigated if, in the first instance, we deal with the common representatives of the class. Thereafter we may profitably attempt the consideration of the pearly nautilus and the general relatives of the cephalopods in time past and in the geological æons wherein lies the childhood as well as the past perfection of the race.

Amongst the ordinary or two-gilled cuttlefishes, various diversities of external form are readily discernible. The elongated body of the squids, or *Teuthidæ*—a group first defined by Aristotle himself—terminated by its arrow-shaped fin, presents us with a characteristic cuttlefish form. The sepias, in which the body is of rounded form and bordered by a soft fin, constitute a second familiar type, and the octopi, in which the body is of globular shape and of which the arms are connected by intervening webs for a considerable portion of their extent, represent a third illustration of the variety of external configuration in these animals. But under the relatively slight variations in form exhibited by the cuttlefishes, there exists a general agreement in bodily structure which renders their examination a tolerably easy matter. The body in all, for example, is enclosed in a muscular mantle-sac—the "mantle" being the name given to the general investing skin or integument of the molluscs at large. It is this "mantle," or "pallium," as it is technically named, which forms the "shell," wherever that structure is found, and under whatever guise it is represented. When we regard an octopus or squid, we are looking at the outer surface of the "mantle," which thus, by its disposition and arrangement, practically forms the body of these animals. Where an external and true shell exists in cuttlefishes, we shall find that this structure simply represents the outer protection of the mantle or integument which has secreted and produced it.

One of the most remarkable traits of cuttlefish existence is the curious play of "shot" colours which takes place in their integument. I have seen a loligo, or squid, stranded on the sea-beach make glorious its dying agonies by a play of colours of the most astounding description. The natural purplish tint of the body was now and again deepened to well-nigh a dark blue; the slightest touch served to develop a patch of angry pink; and continually over the whole surface of the body the hues and tints, ranging from dark purple to light red, succeeded each other in rapid array. This chameleon-like property of the skin of the cuttlefishes was familiar to the classical poets and naturalists. Oppian speaks of the cuttles, when

New forms they take, and wear a borrowed dress,
Mock the true stone and colours well express;
As the rock looks, they take a different stain,
Dapple with grey, or mock the livid vein;
Thus they, concealed, the dreaded danger shun,
By borrowed shapes obscured, and lost in seeming stone.

So, also, another classic writes—

Remark the tricks of that most wary polypus,
Which always seems of the same colour and hue
As is the rock on which he rests.

The assimilation of an animal's colour to the surfaces on which it rests forms a notable circumstance of zoology, which has been denominated "mimicry." Under this head are included all phenomena which enable an animal to assume the form, likeness, or colour of another animal, of a plant, or of an inorganic object. That cuttlefishes possess such a power is well known. The hue of an octopus may so closely resemble that of the rock to which it attaches itself, that the observer can with difficulty say which is rock and which is animal. A flounder's colour is in the same way assimilated to the sand on which it rests, although in the fish the alteration of colour seen in the cuttlefishes is not represented.

The manner of production of the changes of hue and play of "shot" colours in the cuttlefishes is really analogous to that whereby the famed chameleons effect their alterations of hue. Beneath the thin and transparent cuticle or outer integument, and embedded in the dermis or under-skin itself, lie certain contractile colour-cells which receive the name of *chromatophores*. These, by alteration of their granular colour-granules under the stimulation of light or imitation, produce the changes of hue. Rapid diffusion and extension of these cells will produce the appearance of the diffused play of colour so familiarly seen in these animals, whilst certain highly refractive corpuscles, named *Flitterchen* by German physiologists, aid in producing the shot colours, by light-interference. It is interesting to note that in the common frog changes of colour are perceptible in the skin, and are effected by analogous methods to those which produce the variations in hue of the cuttlefishes. Thus the pigment-cells of the frog's skin contract under the stimulus of light, their colour-granules are huddled into the centre of the cell, and the skin becomes blanched. When the stimulus is removed, the pigment-cell expands, its granules are diffused, and the frog's skin resumes its normal coloration. It is noteworthy that in groups of animals so distinct as those just mentioned, one should find closely allied means for attaining a similar end. This remark holds good of other structures in cuttlefishes, which, although of independent origin, subserve functions allied to those performed by the structures and organs of Vertebrata.

The locomotion of the cuttlefishes forms a point of interest in

connection with their general structure and physiology. Any one who has attentively watched the movements of an octopus in its tank must have been struck by the literally acrobatic ease with which it accommodated itself to the exigencies of its life and surroundings. In their lithe, muscular, and flexible arms, the cuttlefishes possess an apparatus which is equally serviceable for the capture of prey, and for walking mouth downwards—that is, in their structurally natural position. They possess, likewise, the power of swimming upper side forwards—or popularly stated "backwards"—by means of the jets of water which, by forcible contractions of the muscular mantle-sac, are projected from the tube or "funnel," situated on the hinder face of the body. These *jets d'eau* consist of the effete water which has been used in breathing, so that the act of expiration and the effete water of respiration together become utilised, in the economical wisdom of nature, as a means of propulsion. The mysterious backward flight of an octopus through its tank (fig. 5) when, detaching itself from its hold on the rock, it swims gracefully and swiftly through the water, is effected in the manner just described. This form of hydraulic apparatus, imitated in experiments in marine engineering, serves but to strengthen the wise man's adage concerning the utter lack of novelty in terrestrial and mundane things.

It is equally interesting to note that some of the squids or loligos —named popularly "flying squids"—appear to be able to rise from the surface of the sea and to spring into the air after the fashion of the flying-fishes. Pliny, in his "Natural History," says, "Loligo etiam volitat, extra aquam se efferens, quod et pectunculi faciunt sagittæ modo;" whilst Varro insists that the name "loligo" is itself a corruption of "voligo." The initial velocity of these cuttlefishes, acquired by their rapid propulsion through the water, enables them thus to career for a short distance through the air. Instances are mentioned of the flying squids having occasionally landed themselves on the decks of ships in their atmospheric leaps.

The "arms" or "feet" demand, however, a somewhat detailed mention, on account of their armature. In all cuttlefishes, save the exceptional pearly nautilus, the arms are either eight or ten in number, and are provided with *acetabula*, or "suckers." Those cuttles in which ten arms are present—and of these the squids and sepias form good examples—have two of these appendages produced beyond the remaining eight in length. Aristotle noted in his day this peculiarity of the ten-armed cuttles. Speaking on this point, he remarks that all of these animals "have eight *feet* provided with a double series of suckers, except in one genus of Polypi"—the genus *Eledone*, in which there is but a single row of suckers. "The sepia, teuthides, and teuthi (that is to say, the sepias and squids) have besides two long *proboscides*, the extremities of which are beset with

a double series of suckers." The two "proboscides" of Aristotle are the "tentacles" of the modern naturalist; and Pliny, speaking of the uses of these tentacles, remarks that they may be used for the capture of prey at a distance, or may be employed to anchor their possessors safely amid the boisterous waters. The "suckers" (fig. 6, A), which constitute a most noteworthy armament of the arms, are borne on short stalks in the ten-armed cuttlefishes, but are unstalked in the eight-armed species. Each sucker (fig. 6, B) exhibits all the structures incidental to an apparatus adapted to secure effective and instantaneous adhesion to any surface. It consists of a horny or cartilaginous cup (*a*), within which are muscular fibres converging towards its centre, where they form a well-defined plug or piston (*b*). By the withdrawal of this plug a partial vacuum is produced, and the suckers adhere by atmospheric pressure to the surface on which they are placed. The sucker is released by the projection of the plug and by the consequent destruction of the vacuum. The number of the suckers varies, but is always considerable; and when we reflect that the array of suckers can be instantaneously applied, and that their hold is automatically perfect, the grasp of the cephalopods is seen to be of the most efficient kind. In some cuttlefishes, and most notably in the so-called "hooked squids" (*Onychoteuthis*), the pistons of the suckers are developed to form powerful hooks, by means of which the prey may be secured with additional facility; and in the common squids the margin of the sucker is provided with a series of minute horny hooks. The "arms" themselves, it need hardly be remarked, are extremely mobile; they are highly muscular, and can be adapted with ease to the varied functions of prehension and movement they are destined to subserve. As regards their arrangement, they are arranged in four pairs—a dorsal and a ventral pair, and two lateral pairs; the two elongated tentacles, when developed, being situated between the third and fourth pairs of arms on the ventral or lower surface.

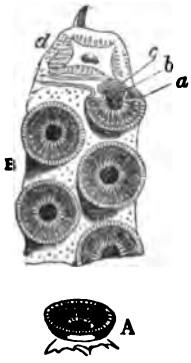

FIG. 6.—SUCKERS OF THE CUTTLEFISH.

The systematic examination of any single animal form, or of any one group of animals, resolves itself into a consideration of the various systems of organs whereby the work (or physiology) of the being or beings is carried on. Primarily, the scientific pathway conducts us to the animal commissariat or alimentary system as a fair starting-point; thence to the blood-circulating system; thirdly, to the excretory apparatus, consisting of the breathing organs, kidneys, and like glands; fourthly, to the nervous apparatus, exercising the

function of "relation;" fifthly, to the reproduction and development of the organism, as demonstrating not merely its affinities with other beings, but likewise its evolution; and lastly, to the distribution of the animal or group in the world as it at present exists, and likewise in the epochs of the past. Our study of the present of the cuttlefishes may, therefore, resolve itself into a brief notice of these successive features; the consideration of their present history leading us naturally to correlate that present with their past, in considering the probable evolution of the race. Incidental to such a systematic survey of cuttlefish structure and physiology, we may touch now and then upon matters which have served more than once as the starting-points of a philosophy leading from the consideration of a mere group of interesting animals, to questions bearing upon the origin and modification of the whole universe of life.

The alimentary tract or digestive system of the cuttlefish race is in every respect of well-developed and complete character. Lower down in the molluscan series the commissariat department is subserved by a very perfect digestive apparatus, including representatives of most of the organs familiar enough to us in higher or vertebrate existence. In the cephalopods we should naturally expect the standard of lower molluscan organisation to be further elaborated; and this anatomical expectation is justified by the actual details of cuttlefish structure. The mouth opens on the upper surface of the head—a disposition of matters already accounted for when considering the relations of the cuttlefish body to that of other molluscs. The mouth-opening is usually bounded by a raised lip, and leads into a cavity containing an elaborate apparatus, analogous to the jaws of higher animals, and by means of which the food of these animals is triturated and divided. An inspection of the masticating apparatus of a cuttlefish readily solves the question, "How are the hard shells of their crustacean food broken down?" There exists within the mouth, firstly, a hard horny beak, resembling closely in shape the beak of a parrot, and consisting of two chief divisions, whereof one—the front—is the smaller, and is overlapped by the hinder beak. Set in action by appropriate muscles, these beaks divide the hard parts of the food with the greatest ease. But a second apparatus of more typical nature likewise exists in these animals. This is the *odontophore*, a structure popularly named the "tongue," and which is common to the whelk and snail class, to the sea-butterflies, and to the cuttlefishes. It consists essentially of an elongated ribbon-like structure, bearing hooked teeth, generally disposed in transverse rows. This apparatus, set in action by special muscles, and worked after the fashion of a chain-saw, is used to rasp down the food; whilst new growths of its substance from behind serve to repair the loss caused by the friction to which it is subjected.

From the mouth-cavity leads the gullet, which may dilate to form a crop in some cases (*octopus*, *argonaut*, *nautilus*, &c.), and which terminates in the stomach. This latter, again, is usually of capacious extent, and as a rule has its gullet opening in close proximity to the intestinal aperture. It is besides extremely muscular. The intestine is bent upon itself; it may possess a spirally twisted portion at its commencement. It is as a rule relatively short, and destitute of the convolutions commonly seen in this part of the digestive tract in higher animals. It terminates in the "funnel" through which, as already remarked, the effete water of respiration is ejected.

If the digestive system of any animal be legitimately described as merely a tube passing through the body of the organism, such a definition must likewise take account of certain lateral appendages or "glands" which secrete, from the blood, fluids required for the digestion of the food. Such are the salivary glands, the liver, and the pancreas or sweetbread of higher animals. These glands are represented in the cuttlefishes by organs of definite nature. Thus the salivary glands open into the mouth-cavity, and number two or four. The liver is proportionately large in cuttlefishes, its bile being conveyed into the digestive tract by two bile-ducts, around which are clustered certain structures regarded as the representatives of the "sweetbread" or *pancreas*. The digestive system of the cuttlefishes is thus seen to be of very perfect nature, and to partake of that high degree of specialisation which, from their position in the molluscan type, we should naturally expect their internal economy to exhibit.

The products of digestion pass directly from the digestive system into the bloodvessels. There exists in no invertebrate, any representative of the absorptive system of vessels whereby the fluid which is to form the blood is removed from the digestive tract and poured into the blood current. But the circulation of the blood itself—which is colourless and, curiously enough, contains copper—is carried on in cuttlefishes by a well-developed system of vessels connected with a central heart. The heart itself consists practically of three chambers or compartments—one ventricle or propelling chamber and two auricles. Like every other heart, that of the cuttlefishes is a hollow muscle—hollow, to allow blood to pass through it, and muscular, to propel the blood from its precincts. Two main bloodvessels arise from the ventricle, which by its constant action is thus distributing pure blood—which it has received from the gills (and auricles)—through the body. The arteries appear to end in capillary vessels, but, according to Milne Edwards, the veins possess more the character of *sinuses* or irregular channels than of well-defined vessels. By the veins, the blood, rendered impure by its circulation through the body, is returned to the gills for purification. The great veins carrying blood to the gills expand at the base of each gill to form two

cavities, named "branchial hearts" or "gill-hearts," which contract in a rhythmical manner and correspond in function to the right side of the human heart, in that they propel venous blood into the organs of respiration. According to Huxley, these "branchial hearts" pulsate in *Loligo media* about sixty times per minute. The work of excretion, or the elimination of the waste materials produced by the actions of existence, is effected in cuttlefish-existence, as in human physiological history, by the organs of respiration and by the kidneys or their representatives. The skin-surfaces, of importance as an excretory apparatus in man, do not appear to be associated with the elimination of waste materials in the cuttlefishes. The impure blood gathered from all parts of the body is at last received by two main or terminal veins, one for each gill. Each of these veins appears to pass through a chamber or cavity which in turn opens into the cavity of the mantle, whence the effete water of respiration is ejected by the funnel. That part of each vein which lies within this cavity, and which is bathed in the water the compartment contains, has a glandular structure. Hence it becomes clear that, as the blood traverses this glandular portion of the vein, certain waste matters are removed from it, and transferred to the water of the mantle cavity and thus got rid of. The glandular parts of these veins, in a word, represent the kidneys of higher animals, and earthy matters containing phosphate of lime are found in the chambers traversed by the veins in question. These mineral concretions have doubtless been eliminated as waste materials from the blood.

The gills, as already noted, number two in all cuttlefishes except the pearly nautilus, and may demand a special notice. Each gill is a conical organ, consisting essentially of a dense network of blood-vessels, in which impure blood brought by the great veins is exposed to the action of the oxygen contained in the water which is being continually admitted to the gill-chambers. Each gill is contained within a kind of chamber, to which water is admitted by the front edge of the mantle-sac. This opening being closed by a valve against the exit of the water, the forcible contraction of the body-walls ejects the water, as previously described, from the "funnel." The gills are themselves contractile, but they do not possess the armament of minute vibratile processes or *cilia*, so typical of the gills of other Mollusca. The need for these cilia as organs providing for the circulation of water over the gill-surfaces is of course removed, in view of the very perfect means existent in the cuttlefishes for the renewal of the water used in breathing. As a living octopus or other cuttlefish is watched, the movements of inspiration and expiration are plainly indicated by the expansion and contraction of the body-walls, and they imitate in a singularly exact fashion the analogous movements of the highest animals. Observers have like-

wise described in certain members of the cuttlefish class a series of minute pores, by which water enters the great veins and mixes with the blood. It is also certain that water enters the general body cavity and bathes the organs of the animal, thus converting that cavity into a physiologically active space, possessing an influence on the circulation in that its contained water presents a medium for the conveyance of oxygen into, and for the reception of waste materials from, the blood.

Connected on the one hand with the digestive system, and on the other with the more purely glandular structures of the body, is the organ known familiarly as the "ink-bag" of these animals. The cuttlefishes are well known to utilise the secretion of this sac as a means of defence, and for enabling them to escape from their enemies. Discharging the inky fluid through the "funnel," into which the duct of the ink-sac opens, it rapidly diffuses itself through the water, and enables the animal to escape under a literal cloak of darkness. The force of the simile under which an over-productive writer is likened to a cuttlefish, may be understood and appreciated when the physiology of the ink-sac is investigated. It is this feature of cuttlefish organisation which Oppian describes when he informs us that—

> Th' endangered cuttle thus evades his fears,
> And native hoards of fluid safely wears;
> A pitchy ink peculiar glands supply,
> Whose shades the sharpest beam of light defy;
> Pursued, he bids the sable fountains flow,
> And wrapt in clouds, eludes th' impending foe.

The exact nature and relationship of this ink-sac to the other organs of the cuttlefish have long been disputed. According to one authority, the ink-bag represented the gall-bladder, because in the octopus it is embedded in the liver. From another point of view, it was declared to represent an intestinal gland; whilst a third opinion maintained its entirely special nature. The ink-sac is now known to be developed as an offshoot from the digestive tube; and, taking development as the one infallible criterion and test of the nature of living structures, we may conclude that it represents at once a highly specialised part of the digestive tract, and an organ which, unrepresented entirely in the oldest cuttlefishes, has been developed in obedience to the demands and exigencies of the later growths of the race. It is this ink-sac which is frequently found fossilised in certain extinct cuttlefish shells. Its secretion forms the original *sepia* colour, a term derived from the name of a cuttlefish genus. The fossilised sepia has been used with good effect when ground down. The late Dean Buckland gave some of this fossil ink to Sir Francis Chantrey, who made with it a drawing of the specimen from which it had been taken; and Cuvier is said to have used this fossilised ink in the preparation

of the plates wherewith he illustrated his "Mollusca." At the present time, recent cuttlefish ink is said to be utilised in the manufacture of ordinary artist's "sepia."

The due regulation of cuttlefish existence is determined by the action of its nervous apparatus. Every living being exercising the functions of a nervous system may be said to perform the function of "relation;" that is to say, it is brought, through the operation of its nervous apparatus, into relation with the outer world. The higher the nervous system, the more perfect are the relations between its possessor and the outer world. In comparing a mussel with a snail, and the latter or both with a cuttlefish, the differences between a low and a high nervous apparatus may be plainly seen. The mussel, possessing a distinct nervous system, lives, nevertheless, a vegetative existence. It exhibits little activity; it has no distinct head; its energies are cabined, cribbed, and confined within the compass of its shell; it may "hear" dimly, it is true; but its relations with the outer world are limited to the sweeping in and to the reception of food particles in the water it receives, and to the occasional closure of its shell when alarmed. Mussel life passes, therefore, through an uneventful history.

The snail, on the other hand, exhibits a livelier interest in the affairs of the universe. Possessed of head, sense-organs, and motor powers, its means of relating itself to the outer world are of an infinitely superior kind to those possessed by the mussel. It quickly retires into private life and into the cavity of its shell when alarmed; it hears and sees, and its capacities for acting and reacting upon its surroundings are of a tolerably advanced nature. The cuttlefishes in turn present us with a marked advance upon the innervation of the snails and their allies. The cephalopods are infinitely more active, in turn, than the slow-moving gasteropods, and their nervous axis exhibits additional specialisation and development, as becomes their more elevated position.

The ordinary type of molluscan nervous system undergoes in the cuttlefishes a decided change of form. In a snail or whelk, for example, the nervous system exhibits an arrangement of three chief nerve-masses or "ganglia," connected by nervous cords. Of these three nerve-centres, one is situated in the head, a second in the "foot" or organ of movement, and a third in the neighbourhood of heart and gills, or amidst the viscera generally. Increased concentration of this type of nerve-arrangement awaits us in cuttlefish organisation. Just as the spider possesses a more concentrated and localised nerve-axis than the insect, or as the gangliated chain of the latter becomes the fused nerve-mass of the spider; so in the cuttlefish, the molluscan nerve-system, scattered and diffused in the snail, whelk, or mussel, becomes localised in adaptation to the increased nerve-control and

to the wider instincts of cuttlefish existence. This process of nerve-localisation and concentration is accompanied by certain important modifications affecting other regions and structures of cuttlefish economy. Thus the nerve-centres are found to be protected and enclosed within a gristly or cartilaginous case, that foreshadows the functions of the vertebrate skull, though in no sense connected with that structure; and the structure of the cuttlefish eye is likewise peculiar, and presents a noteworthy feature of the economy of these animals. Altogether, the disposition of the nervous axis presents us with one of the most characteristic studies in cuttlefish history, and offers at the same time, perhaps, more interesting problems in connection with the evolution of the race than any other system of organs included in the list of their bodily possessions.

The first modification to which attention may be directed is the massing of the nerve-centres around the gullet in the cuttlefishes. Gathered up, as it were, from the foot and viscera, we find the chief nervous masses disposed within the head region, and further enclosed within the cartilaginous case or "skull" already mentioned. This concentration of nerve-masses in the cephalic or head region is in itself noteworthy. It teaches us that the tendency to "cephalisation," as Professor Dana has termed the process of head-development, is largely associated with, if not directly induced by, this nervous concentration; and it likewise reveals one of the main causes of superiority and advance in the animal series. But the presence in the head of the cuttlefishes of the cartilaginous "skull," in addition to sundry other masses of gristle scattered through the substance of the "mantle," has just been mentioned as a feature of interest. No possible lines of connection, genetic or otherwise, exist between cuttlefishes and vertebrates; yet this "skull" character would at first sight seem to indicate resemblance and relationship of a definite kind between the two groups. But the case before us merely adds one to already known instances in which structures of analogous or similar nature have originated in a perfectly independent fashion. Such a result, however, does not, as has been argued, lie outside those normal laws of progressive development through the operation of which the universe of life has become the wondrously complex thing it is. The vertebrates themselves exhibit a progress of skull development leading us from that skull-less, spineless, boneless fish the lancelet (*Amphioxus*), through the imperfectly differentiated crania of the lampreys and their allies, to the complex skulls of our common fishes, and upwards by diverging lines to crania of higher type still. Is it any the more anomalous to find in the cuttlefishes the progressive development of a protective case for the modified and concentrated nerve-centres? Considering that the cephalopods stand at the extreme limit of molluscan deve-

lopment, it becomes a postulate of evolution that in them we should find the cumulative increase and progress of their type. Thus cuttlefish specialisation, so far from placing any difficulties in the way of evolution, supplies additional proof of the growing applicability of that doctrine to unravel the complexities of living structures. Furthermore, as we advance from the older to newer types of cuttlefish life, the "skull" becomes better developed. It is better developed in the two-gilled cuttlefishes, which are forms literally of the geological yesterday, than in the pearly nautilus, which presents us with a cuttlefish type of vast antiquity. In the nautilus the skull consists of two pieces, surrounding the gullet at its commencement; but in the two-gilled cuttlefishes it exhibits a middle portion, through which the gullet passes, and likewise shows side-processes that form cavities or "orbits," enclosing the eyes as in higher animals. Within this case the three localised nerve-masses exist. Here, again, we discover that in the later cuttlefishes the nervous axis is more concentrated than in the earlier forms—modification of, and progress in, structure accompanying development in time. A large nerve-mass, consisting of the three closely connected centres, thus subserves the function of a cuttlefish brain. Not the least interesting feature of this localised mass of nervous matter is the fact that it exhibits the same arrangement of grey and white nerve-matter that is seen in the highest brains. An outer grey and an inner white layer are discernible in the nerve-ganglia of cephalopods, as in the cerebrum of man; and, as in the highest animals, the cuttlefish grey matter is found to consist of nerve-cells, whilst the white matter is chiefly composed of nerve-fibres. Thus the laws of developmental progress affect the microscopic and intimate structure of the living form as well as the more obvious details of structure. From the main nerve-mass of the cuttlefishes nerves arise to supply the body at large. Nerves of special sense supply eyes, ears, and olfactory organs; whilst the viscera and the "mantle" or general body-covering are also well provided with the means of innervation.

Cuttlefish existence possesses in all probability the five "gateways of knowledge," through which the impressions of the outer world are received, and by which these impressions are modified and transmitted to the brain-masses as sensations of sight, hearing, smell, touch, and taste. There is little need to draw upon hypothesis in the assumption that the arms or tentacles are efficient organs of touch in Cephalopoda, or that the structures of the mouth may subserve taste, in so far as the latter sense may be required to satisfy the demands of cuttlefish existence. An organ of smell is definitely situated behind or above the eyes. There, two small projections or, as frequently, two minute pits or depressions, occur. These pits are ciliated, and between the cilia "olfactory cells" are situated

These cells in turn represent the similar structures which occur in higher animals, and which in man himself form the characteristic terminations to his olfactory nerves. That the cuttlefishes can literally scent their prey from afar off, is an idea confirmed by the facts of their every-day life. A well-developed organ of smell necessarily confers upon them a great advantage in the struggle for food in which, along with the other tribes of the sea, they unquestionably share.

The "ears" of the cuttlefishes present us with two sacs—named "auditory sacs"—which may, as in the nautilus, either be attached to the chief nerve-mass itself, or, as in the two-gilled cuttles, be lodged in special cavities in the gristly "skull." A cuttlefish "ear" is essentially a sac or bag, called an "otocyst," containing either one or many "otoliths" or "ear-stones," suspended in a watery fluid. This, indeed, is the primitive type of "ear" we may find even in the *Medusidæ* or "jelly-fishes" themselves. The manner in which this hearing sac exercises its functions is not difficult to trace. Vibrations of sonorous kind, transmitted to its substance, set the otoliths in motion. This motion, along with that of the contained fluid of the otocyst, is communicated to the "end cells"—bearing delicate processes known as "auditory hairs"—in which the fibres of the auditory nerves end. Thus the "ear-sac" of a cuttlefish is simply a body adapted for the reception of sound-waves, and for the modification of these waves, which, as they impinge upon the fine ends of the nerve-fibres of the sac, become transformed into impressions of sound. These impressions are in due course transmitted to the brain or ganglionic mass of the animal, which, like that of other organisms, acts upon the "information received" with an intelligence and completeness proportionate to the perfection of its structure and functions. The ear-sacs of many cuttlefishes open on the external surface of the body by two fine canals, named "Kolliker's ducts," after their distinguished discoverer. Occasionally these ducts end blindly, and do not open on the body surface. These facts lend additional support to the opinion that in the ear of the cuttlefish we find primitive structures proper to the ears of vertebrates, the minute canals of Kolliker corresponding with the *recessus vestibuli* of the vertebrate organ of hearing. Once again, therefore, we find the progressive development of cephalopods and vertebrates running in parallel, but nevertheless in distinct and independent, lines; and this likeness is further strengthened when we discover that not merely the ear, but the eye likewise, of these two groups of animals is formed or developed in an essentially similar fashion. The ear of the cuttlefish presents us with a permanent example of an early and transitory stage in the development of the vertebrate ear, and a common plan of ear-production is thus seen to traverse a wide extent of the animal world.

Those who are acquainted with even the superficial details of the

history and progress of the theory of evolution, amidst the critical warfare through which in the days of its youth it was fated to pass, will remember the somewhat famous controversy regarding the eyes of cuttlefishes and their relations with vertebrate eyes, in which Mr. Darwin and Mr. St. George Mivart took part. The latter, insisting upon the likeness of the cuttlefish eye to the vertebrate eye, laid stress upon this likeness to enforce his argument that, as such likeness could not be "due to inheritance from a common progenitor, it would be difficult if not impossible to explain such likeness as arising by the slow variation postulated by Darwin's theory of natural selection." Mr. Mivart's words are clear enough. Speaking of the presumed

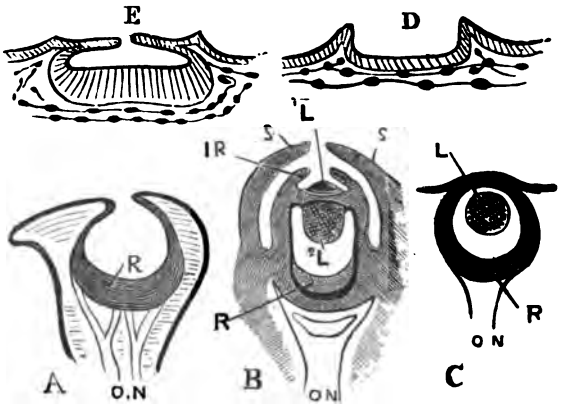

FIG. 7.—DEVELOPMENT OF THE CUTTLEFISH EYE.

A, Section of eye of Nautilus; B, of Two-gilled Cuttlefish; C, of a Snail; D and E, Early stages in formation of eye. References correspond in all the figures: L' L², lens; I R, iris; S S, cornea; R, retina; O N, optic nerve.

likeness between the eyes of vertebrates and cuttlefishes, he says, "There can hardly be any hesitation in saying that for such an exact, prolonged, and correlated series of similar structures (sclerotic, retina, choroid, lens, &c., of the eye) to have been brought about in two independent instances by merely indefinite and minute accidental variations, is an improbability which amounts virtually to impossibility."

The primary difficulty, that of the development of the eye in any group by gradual and progressive modification, is, however, solved and obliterated by the history of the individual development of any single eye in that group. Mr. Mivart's specific difficulty, that of the causes of the likeness between cuttlefish eyes and vertebrate eyes, vanishes away when the progress of research demonstrates that the likeness in question is only apparent. For in truth there exists

between these eyes just that amount of distinction and variation which the evolutionist would expect to find in products and structures of two varied and divergent twigs of the tree of descent. Darwin remarks, in reply to Mr. Mivart, that Hensen's memoir on the cuttlefish eye incontestably shows the difference between that organ and the eye of Vertebrata. The only likeness is that implied in vision of all kinds—a transparent organ, containing a lens "for throwing an image at the back of a darkened chamber." When the two eyes are carefully compared, the differences become prominent and apparent. Thus, as Mr. Lankester has shown, the eye of the cuttlefish begins its development as a pit (fig. 7, D) in the *epiblast* or outer layer of the embryo. Around this pit grows a fold which, as its edges meet in the middle line (E), shuts off the pit from the exterior. The epiblast lining the front of the pit or vesicle becomes the ciliary body and processes of the eye, whilst that lining the back of the vesicle gives origin to the retina (R). Then the pit becomes a closed sac, and a third layer (*mesoblast*) grows between the outer epiblast and its wall. The lens of the eye now forms in two pieces. The inner piece grows from the front wall of the pit or vesicle into its cavity, and ultimately the lens exhibits the characteristic double structure (B, L^1 L^2) of the adult cuttlefish eye. The iris (IR) grows outside the optic vesicle in front, in the shape of two folds, whilst external to the iris other two folds (S S) form the front chamber of the eye. This front chamber may or may not remain closed; usually it opens externally by a small aperture (B) which persists in the middle of the cornea.

Thus there can be little hesitation in affirming that a study of the eyes of the cuttlefishes teaches two important lessons: Firstly, that their development adds another proof to the already overwhelming amount of testimony which supports the doctrine of evolution. In the course of its development the eye of one of the higher or two-gilled cuttlefishes (B) passes through stages which correspond with the permanent condition of the eye in the nautilus (A), in which there is neither lens, vitreous humour, nor cornea, the eye being merely a vesicle or sac lined by the retina (R), and opening externally by a very small aperture. Just before the optic pit becomes closed (E), the permanent state of the nautilus eye is duly figured forth. Again, at a later stage, when the vesicle is closed (C) and when the lens (L) projects into it, the condition of eye common in the adult gasteropod is imitated. The development of a single higher cuttlefish eye (B) is, in fact, a panorama of the evolution of molluscan eyes at large.

A second lesson taught us by the investigation of the organ of sight in cuttlefishes is that of hesitation in assuming or rejecting the genetic relationship of living forms, or in criticising the possibilities of evolution, until exact research has placed the determination of

these relationships and of the ways of development within our grasp. Thus a study of the cuttlefish eye proves that, whatever its complexities, it represents the advanced and modified result of the development of lower molluscan eyes. Such a study also corrects erroneous notions of the genealogy of the animal world. The presumed relationship between vertebrate and cuttlefish eyes disappears at once under the light of Hensen's researches. As Darwin so well puts it, in speaking of the difference between these two eyes, "The crystalline lens in the higher cuttlefish (fig. 7, B) consists of two parts (L^1, L^2), placed one behind the other like two lenses, both having a very different structure and disposition from what occurs in the Vertebrata. The retina is wholly different, with an actual inversion of the elemental parts, and with a large nervous ganglion included within the membranes of the eye." Then, in further detailing the disappearance of the difficulties started by Mr. Mivart, Darwin says, "It is of course open to any one to deny that the eye in either case (cephalopods or vertebrates) could have been developed through the action of natural selection of successive slight variations; but if this be admitted in the one case, it is clearly possible in the other; and fundamental differences of structure in the visual organs of two groups might have been anticipated, in accordance with this view of their manner of formation. As two men have sometimes independently hit on the same invention, so in the several foregoing cases it appears that natural selection, working for the good of each being, and taking advantage of all favourable variations, has produced similar organs, as far as function is concerned, in distinct organic beings, which owe none of their structure in common to inheritance from a common progenitor."

Passing now to consider the reproduction and development of the cuttlefishes, we note that the two sexes are completely defined, and that the young are developed, as are those of all other animals, from eggs. Certain curious details are connected with the act of egg-fertilisation in this group. The males exhibit an unsymmetrical condition of their arms in that one or more of these organs becomes specially developed to form what is known as the *hectocotylus*, and by which fertilisation of the ova is effected. This arm is the third right arm in octopus, and the third left in the argonaut (fig. 9, C, *a*). When first discovered, this hectocotylised arm was regarded as a parasitic organism. In sepia it is the base of the arm which undergoes alteration, whilst in octopus it is the tip which is most modified, the extremity of the arm being converted into a spoon-like process. In the argonauts, and in Tremoctopus as well, the highest modification of the arm for reproduction is witnessed. Here, the arm itself is formed within a sac or vesicle, from which, at maturity, it is released. Its extremity is prolonged to form a whip-like lash, and this modified organ is itself

ultimately destined to be detached from the head of its possessor, and to be directly applied to the fertilisation of the ova.

The development of the cuttlefishes presents us with a subject of exceeding interest. That of nautilus is unknown; but the development of the two-gilled forms shows us exactly what the theory of their evolution would lead us to expect—namely, that, as representing an extremely ancient and modified molluscan stock, the phases of their development should be more or less obscured, concentrated, and modified. A long ancestry leaves its mark on the development of a class. The modifications of form, the shifting environments, and the other conditions of organic change, to which an ancient race must unquestionably have been subjected, undeniably tend to shorten the developmental process, and to obliterate the ancestral phases so plainly seen, as a rule, in life-histories of shorter extent. The egg undergoes partial segmentation, and the *blastoderm* or *germinal membrane*, from the substance of which the embryo is formed, beginning to appear on one aspect of the egg, soon extends over the whole egg-surface. This blastoderm soon develops its three characteristic layers, hypoblast, mesoblast, and epiblast. Then, in the middle of the blastoderm, appears a patch of substance representing the future mantle or investing skin of the body. In the centre of this mantle is a depression which gives origin to the shell, and is named the "shell-gland." Two curved folds on each side become the "funnel." In front the two eyes are developed. Behind the mantle are two buds which ultimately develop into the gills. The arms likewise begin to appear at an early stage of development, whilst the head-fold, with which the arms are to be so intimately related, is developed as two swellings, one on each side of the growing mass. Even after the embryo has attained a tolerable size, the "yolk-sac" persists, its substance being gradually absorbed to afford the wherewithal for the building of the new and developing frame. On comparing the development of a cuttlefish with that of an ordinary mollusc, such as the whelk or mussel, grave differences in development, alluded to in a former part of this discourse, are apparent. Thus the embryo cuttlefish is exceptional in possessing an external yolk-sac; it shows no "foot" in the course of its development; instead thereof it develops the characteristic arms; and it lastly has no "velum" or ciliated disc, which forms such a prominent feature in the development of other Mollusca. Cuttlefish development, exhibiting in its phases a concentration of some and an obliteration of other molluscan characters, testifies to the modification, as well as to the progressive development, which the race in time has undergone.

The present history of the cuttlefishes may be concluded by the briefest possible reference to their distribution and classification. Over 2,000 species of cephalopods are known. But geology claims

the vast majority, some 300 species, or so, being included in the ranks of living animals. The cuttlefishes are very widely distributed in existing seas. They occur in the far north; they are plentifully represented in the colder seas by the squids which form the bait of the Newfoundland cod-fishers; but in tropical regions they attain their greatest size and numerical strength. Their classification is both simple and natural. Their division into *Dibranchiates* ("two-gilled") and *Tetrabranchiates* ("four-gilled") is a method of arrangement which accurately reflects variations in their existing structure, as it correctly indicates the main lines of their geological and past history. Of four-gilled cuttlefishes there is but one living example—the pearly nautilus (fig. 8). Its special and distinctive peculiarities may be rapidly summed up in the statement that it has four gills, numerous arms (*c*), no suckers, no ink-sac, an incompletely tubular funnel (*f*), stalked eyes, and an external many-chambered shell, in

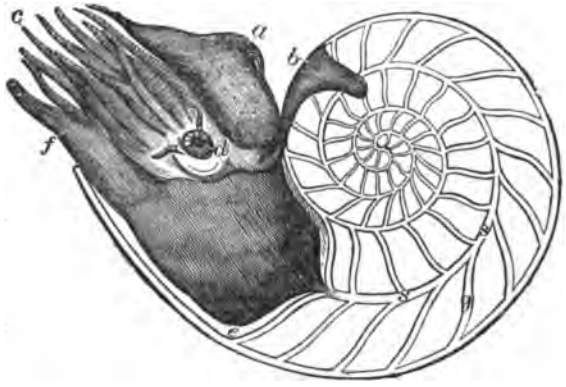

FIG. 8.—PEARLY NAUTILUS. (Shell in section.)

the last-formed and largest compartment (*e*) of which the body is lodged.

The absence of an ink-sac in the nautilus is a fact correlated with its bottom-living habits and with the absence of any need or requirement for the sudden concealment from enemies which the more active two-gilled forms demand. The many-chambered shell of the pearly nautilus exhibits a flat, symmetrical, spiral shape. Its many-chambered state is explained by the fact that as the animal grows it successively leaves the already-formed chambers, and secretes a new chamber to accommodate the increasing size of body. Each new chamber is partitioned off from that last occupied by a shelly wall called a *septum* (*g*). Through the middle of the series of septa runs a tube named the *siphuncle* (*s*, *s*), whose function has been

credited with being that of maintaining a low vitality in the disused chambers of the shell.

All other living cuttlefishes possess, on the contrary, two gills, never more than ten arms provided with suckers, an ink-sac, unstalked eyes, a completely tubular funnel, and an internal shell. If, however, the nautilus represents in its solitary self the four-gilled cuttlefishes of to-day, it likewise, like "the last of the Mohicans," appears as the descendant of a long line of famous ancestors. In its distribution, the nautilus is limited to the southern seas. It is still the rarest of animals in our museums, although its shells are common enough. The scarcity of living nautili appears difficult to account for, when we find Dr. Bennett informing us that the natives of the New Hebrides dive for one species, and likewise capture it in fish falls; the Fijians capturing *Nautilus Pompilius* with lobster-bait. Mr. Moseley tells us that the "Challenger" expedition obtained but a single specimen of the nautilus. It "swam round and round a shallow tub in which it was placed, moving after the manner of all cephalopods—backwards, that is, with the shell foremost. It floated at the surface, with a small portion of the top of the shell just out of the water, as observed by Rumphius." Remarking on the scarcity of the living animal, as compared with the abundance of the shells, Mr. Moseley says, "The circumstance is no doubt due to the fact that the animal is mostly an inhabitant of deep water. The shells of *Spirula* (fig. 11) similarly occur in countless numbers on tropical beaches, yet the animal has only been procured two or three times. We obtained one specimen during our cruise, which had evidently been vomited from the stomach of a fish."

Mr. Moseley further expresses his opinion that "both *Nautilus* and *Spirula* might be obtained in some numbers if traps, constructed like lobster-pots, and baited, were set in deep water off the coasts where they abound in from 100 to 200 fathoms." He adds, "The fact that the living *Nautilus* was obtained from 320 fathoms shows that it occurs at great depths. It is probably a mistake to suppose that it ever comes to the surface voluntarily to swim about. It is probably only washed up by storms, when injured perhaps by the waves."

It is thus the pearly nautilus floats under certain circumstances on the surface of the water. The argonaut (fig. 9), credited in poetry and fiction with this power, never floats on the surface, as was of old believed. It is simply a mundane cuttlefish, whose two expanded arms are never used as sails, after the popularly supposed fashion, but are employed solely to secrete and attach to the body the false shell (fig. 9, A) with which it is provided. Pope's advice—

> Learn of the little nautilus to sail,
> Spread the thin oar and catch the driving gale—

is thus utterly wasted; since his remarks apply to no cuttlefish whatever, and least of all to the argonaut, which, like its cephalopod neighbours, creeps along the sea-bed by aid of its sucker-provided arms, or shoots backwards in the sea by aid of the water-jets from its funnel.

Amongst the two hundred odd living two-gilled cuttlefishes, considerable diversity of external form may be seen; but the general type already described is at the same time closely adhered to; and, save in the case of the paper nautilus or argonaut, in which the characteristic shape of body is concealed by the shell, the cuttlefish

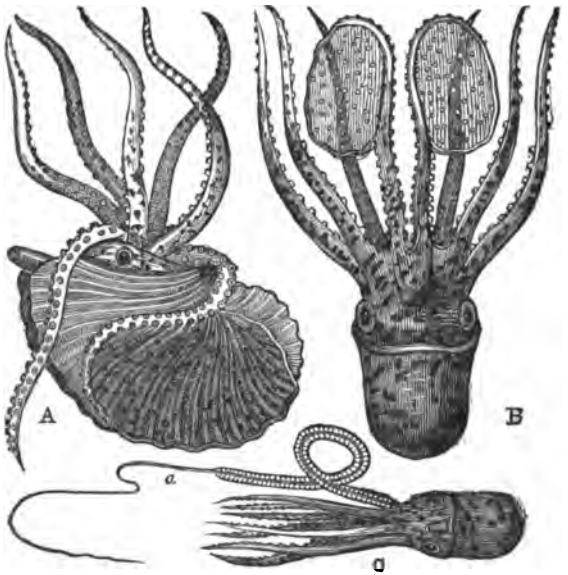

FIG. 9.—PAPER NAUTILUS.

A, Female Argonaut showing shell, around which the two expanded arms are clasped: B, Female removed from shell; C, the Male Argonaut (shell-less).

characters are readily apparent. The shell of the paper nautilus (fig. 9, A) is termed "false" or "pedal," because it is not formed by the mantle, as all true shells are, but by the two expanded arms, as already mentioned. In its homology it therefore coincides with foot-secretions (such as the "beard" of the mussel), and not with the shells of its neighbours. The female argonaut alone possesses a "shell," the male (fig. 9, C) being a diminutive creature, measuring only an inch or so in length.

It is in the ranks of the two-gilled cuttlefishes that we discover those phases of cuttlefish life which most characteristically appeal to the popular mind. Thus, many species of two-gilled cuttles are eaten and considered dainties by foreign nations; it is from this group that the sepia colour already mentioned is obtained; their internal shells gave us the "pounce" of long ago, and formed an article in the materia medica of bygone days; and, lastly, it is in this group that the mythical and the real meet in the consideration of the giant cuttlefishes which the myth and fiction of the past postulated, and which modern zoology numbers among its realities.

Tales of giant cuttlefishes are plentifully scattered through the pages of classic and mediæval narrators. Pliny and Ælian mention cuttles of huge size as having devastated the fishings on the Mediterranean coasts. The Scandinavian legends teem with giant cuttlefishes. Pontopiddan the younger, Bishop of Bergen, if not the inventor of the legend concerning the "Kraken" or colossal poulpe, perpetuated the story of this giant cuttlefish which seized ships in its capacious embrace and destroyed fleets by the score. Denys de Montfort, a French naturalist, in a zoological work depicts the Kraken at work. It is demolishing a three-masted vessel in a style eminently calculated to impress the uninitiated with a due sense of its power; whilst it was this same De Montfort who, from the other side of the Channel, started the story of the destruction of a British convoy and six captured French men-of-war by the herculean cephalopod—the facts of the case, including the safe arrival of the ships at Jamaica, unfortunately for the ingenious *raconteur*, directly contradicting his essay in zoological fable. One may pass by the narrative of Dens, a trader of Dunkirk—also told by De Montfort—in which a giant cuttlefish rose from the sea depths, when Dens's vessel lay between St. Helena and Cape Negro, and seized three of his sailors. An arm of the animal was cut off in valiant defence, and De Montfort gives its length at 25 feet. But whilst Dens's narrative may have been founded on fact, as recent circumstances prove, there seems little doubt that to De Montfort it owed considerable embellishment. Leaving these exaggerations to the fate which posterity invariably reserves for them, we may next note that in the records of zoology, dating from eighty years back, we meet here and there with instances in which the actual remains of giant cuttles were encountered. Peron, Quoy, and Gaimard, Captain Cook, Lander, Rang, and others, detail cases in which cuttlefishes exceeding greatly all ordinary species in size were seen and examined. In 1867, a French war-steamer, when between Teneriffe and Madeira, encountered a giant squid nearly 20 feet long in body alone and without estimating the length of the arms. Within the past few years, however, a large number of specimens of giant cuttlefishes have been met with on the

North American coast. These specimens have been made the subject of scientific examination by Professor Verrill, and they therefore indisputably prove that the cuttlefishes number amongst their ranks forms which present us with living realisations of Victor Hugo's "devil-fish," or even of the fabled Krakens themselves. Thus one specimen found off the Newfoundland coast in 1873 is calculated to have measured 10 feet in length, 2 feet 5 inches in diameter, its longest arms being estimated at 32 feet in length. The body of another squid captured in Conception Bay in November 1874 was 7 feet long, its two tentacles each measuring 24 feet and its short arms 6 feet in length. Specimens of giant squids attaining a length of 19 or 20 feet have been met with off the Irish coast. Professor Verrill describes a specimen cast ashore in December 1874 on the Newfoundland coast as measuring 40 feet in total length, the body alone being about 14 feet long. The longest sucker of this specimen measured 1 inch in diameter. These specimens belong to the squid family, and are included in the genus *Architeuthis*. On the Alaska coast specimens of cephalopods measuring 14 feet in length minus the extremities of the tentacles have occurred; these latter specimens being referred to the genus *Ommastrephes*. Professor Verrill's detailed account of the giant cuttlefishes of the American coast will be perused with interest. There remains no doubt that the stories and legends of the older narrators may have possessed at least a germ of fact. The surprising fact remains that only within the past few years has science been made acquainted with the existence of these giant members of the race. In view of this long-delayed information it may well be questioned whether the sea-serpent itself may not prove a reality of the future; whilst it may be safely assumed that these giant cuttlefishes have more than once played the part of the "great unknown" of the sea-depths, and have been described under the title and guise of unknown "sea-monsters."

The past history of the cuttlefishes unites in itself a knowledge at once of their present position in the animal world and of their progress towards that position. The history of their past begins with the recognition of the pearly nautilus (fig. 8) as an animal which, being a four-gilled cuttlefish and possessing an external many-chambered shell, stands alone in the world of life. It is the tribes of two-gilled cuttlefishes which people our ocean to-day, and which exhibit all the gradations of form and size, from the minute *Spirula* (fig. 11) to the great *Architeuthis* of the American coasts. The history of the cuttlefishes in time begins in the far-back epoch represented by the Lower Silurian rocks of the geologist. There are entombed the first fossil cuttlefishes, represented by their chambered shells. The genus *Orthoceras*, represented by shells of straight form, is thus amongst

the oldest members of the cuttlefish race. The *Nautilus* genus itself begins in the Upper Silurian rocks; we may trace the well-known shells upwards to the Carboniferous strata, where they are best developed; and we follow the genus onwards in time, as it decreases in numbers, until we arrive at the existing order of things, in which the solitary nautilus remains, as we have seen, to represent in itself the fulness of cephalopod life in the oceans of the past. The older or Palæozoic rocks reveal a literal wealth of these chambered shells, and therefore

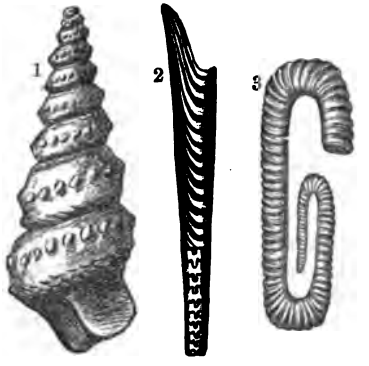

FIG. 10.—SHELLS OF FOSSIL CUTTLEFISHES.
1, Turrilites; 2, Baculites; 3, Hamites; 4, Scaphites.

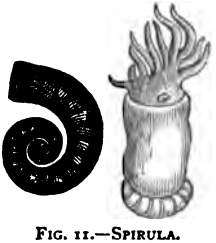

FIG. 11.—SPIRULA.

of the existence of the four-gilled cuttlefishes as the founders of the race. When we ascend to the Mesozoic rocks (ranging from the Trias to the Chalk), we meet with new types of the chambered shells well-nigh unknown in the Palæozoic period. In the Mesozoic rocks appears the fulness of *Ammonite* life. Here we find shells named after the horns of the Egyptian god, Jupiter Ammon; these, instead of being tolerably plain like the *Nautilidæ*, exhibit beautifully sculptured outlines, and folded septa, or partitions, between the chambers of the shell. The shells allied to *Nautilus* and occurring in the Palæozoic formations differ from Nautilus chiefly in their varying degrees of curvature or straightness. *Lituites* is a curved form allied to *Nautilus*; whilst *Orthoceras* and *Gomphoceras* are groups representing the straightened forms. But in the Silurian period more complex forms appear, with elaborate and folded septa. These are the early Ammonites, such as *Goniatites* and *Bactrites*. In the Secondary rocks we find the still more complex true Ammonites themselves. Here the *lobes* and *saddles* of the shells, as the edges of the septa are named, are of the most elaborate patterns, whilst the shapes of shell are of the most varied character (*Baculites*, *Turrilites*, *Ammonites*, &c., fig. 10).

There is an advance and progression exhibited in the de-

velopment of the four-gilled races which accords perfectly with the theory of evolution and descent. The seas of the Trias, Oolite, and Chalk periods must have literally swarmed with these striking forms of cephalopod life; but as the close of the Chalk period dawned, and as the Secondary age came to an end, the fulness of the Ammonite generations disappeared for ever. In the succeeding Tertiary period not a single ammonite of any kind occurs; the genus *Nautilus* remaining in the Tertiary period—as it survived into the Mesozoic or middle period—as the sole representative of a once plentiful four-gilled population.

If the history of the four-gilled cuttlefishes is thus plainly told as having its beginnings in the Palæozoic period, its maximum development in the Mesozoic period, and its lingering presence in the Tertiary period, the two-gilled cuttlefishes may be said to possess an equally interesting history. Compared with their four-gilled neighbours, the two-gilled forms are late-comers upon creation's scene. Not a single fossil two-gilled form occurs in all the Palæozoic period extending from the Laurentian to the Permian rocks. If they existed in Palæozoic seas, they have at least left no trace of their presence. Their softness of body may perchance have contributed to their elimination from the oldest fossil records; but laying aside mere conjecture, we find the first fact of the past history of the two-gilled forms in the presence of the fossil shells of the extinct *Belemnites* in the Triassic rocks. The Belemnites themselves disappear at the close of the Mesozoic period; but fossilised shells of species allied to our living sepias occur in the Oolite; and the internal shells of squids are found in the Lias or lower Oolites. In the Tertiary rocks, argonaut (fig. 9) shells occur in the Pliocene deposits; the Eocene rocks also give us sepia remains; and various other two-gilled fossils (*Beloptera*, &c.) are found in Eocene and Miocene formations.

Briefly summarised, then, we find that the chief details in the past history of the cuttlefishes are told when we are reminded that the four-gilled forms are by far the more ancient of the two groups; that they first appear in the Silurian rocks, whilst the two-gilled forms appear first in the Secondary rocks; and, lastly, that the record of the one group is the converse of the other. For, the four-gilled species attained their maximum in the Primary and Secondary rocks, and have practically died out, leaving the pearly nautilus as their sole representative in existing seas. The two-gilled race, starting in the Secondary rocks, and leaving the extinct belemnites as a legacy to the past, have, on the other hand, flourished and progressed, and attain their maximum, both in size and numbers, in the existing seas and oceans of our globe.

What ideas concerning the origin and evolution of these animals may be legitimately deduced from the foregoing facts of their struc-

ture and distribution in time? In the answer to such a question, asked concerning any group of living beings, lies the culminating point of all biological science. That the cuttlefishes fall nominally into their place in the scale of being indicated by evolution, and that in their individual development, in the growth of their special organs such as eye and ear, as well as in the general relations they bear to each other as living forms, they illustrate the results of progressive development, cannot for a moment be doubted. The further fact that the existing four-gilled nautilus, despite its lengthy ancestry, as regards its brain, its eye, its tentacles, and other features of its history, is a less specialised and lower form than the two-gilled cuttlefishes, clearly points to the evolution of the two-gilled from the four-gilled stock. The preponderance of the latter race in time, and its long and solitary representation of the class, as well as the relatively late appearance of the two-gilled species, are facts which collectively point to the two-gilled forms as derivatives of the older four-gilled race. The more active and structurally higher races of to-day, in other words, have sprung from the less specialised and lower cuttlefishes of the geological yesterday. No question, then, of the reality of progressive development, as a factor in evolving new species and groups of cuttlefishes from the confines of already formed species, can be entertained. It is easy, moreover, to show from the researches of Würtenberger that even in one group—that of the ammonites themselves—the evidence of evolution is full and complete. The *Planulate* or "ribbed" ammonites have, according to this author, given origin to the *Armata*, or spinous forms. The ribs of the one pass by gradual modification, well represented in the fossil shells, into the spines of the other. So closely are these species of ammonites connected that, as Würtenberger remarks, it is almost hopeless to define where one species ends and another begins. The modifications of form which connect one curious shape of shell with another of different shape and species are not sought in vain in palæontological records.

Turning more specifically to the shell in general, we may discover in the modifications of this single structure a clue to the entire evolution of the cuttlefish race. The "shells" of the two-gilled cuttlefishes exist for the most part as horny "pens" or as limy plates, secreted by the "shell-gland" of the mantle which forms the true shell of all molluscs. In considering the nature of the various shells of cephalopods, "palæontology," as Professor Ray Lankester puts it, "crosses the path of embryology." Starting with the shells which are certainly oldest in point of time, and therefore of development, we find in the Nautili and their neighbours, structures which represent fulness of shell-growth. It appears a long hypothetical journey from the well-developed shell of the nautilus-type to the limy plate

or horny "pen" shell of the common squid. But the halting-places on the way diminish the apparent length of the journey, as they lessen the seeming irregularity of the path. The simple rudimentary shells of our two-gilled cuttlefishes, are to be regarded as the degenerate remains of structures fully developed in their ancestors. To this idea, their succession in time bears faithful witness; and to its correctness the connecting links, accessible to us, plainly testify.

Starting with the perfect four-gilled shells as ancestors of the imperfect pens and shells of living cuttlefishes, we may find in some such straight shell as that of *Orthoceras*—a type of shell persisting onwards to the Trias from the Silurian—as likely a form as any other to have evolved the newer races in part. We discover next in the extinct *Belemnites* of the Mesozoic rocks a first halting-place. Already we are in the domain of the two-gilled cuttles; for the belemnite was a kind of squid or calamary, and possessed the ten arms of its race. Evolved from some orthoceras-like or straightened nautiloid ancestor, the belemnite shell bears proof of its descent in its structure. Here we discover a chambered portion resembling the straight nautilus shell; and, combined with the chambers, is an anterior part, the *pro-ostracum*, and a posterior portion, the *guard*. Next in order in the list of connecting forms comes the little *Spirula*, in which an originally outside shell becomes enclosed by the mantle. The shell of Spirula (fig. 11), often termed the "post-horn" shell from its shape, exhibits a spiral form; the coils lying in one plane, but not being in contact as are the whorls of the nautilus shell. The shell of Spirula is practically a belemnite shell, minus a *guard* and *pro-ostracum*. In Spirula, therefore, the transition from an external nautilus-like shell to an internal shell is clearly to be witnessed. In *Spirulirostra*, a fossil and extinct form found in the Tertiary rocks, we have a shell like that of Spirula, but possessing in addition a *guard* imitating that of the belemnites. Within the actual domain of the zoologist, are the shells we discover in the existing sepias. In these animals a limy plate represents the result of degenerative action consequent upon altered life and habits which no longer tend towards shell-perfection. The chambers of the originally outside shell of the spirula type, and the chambered part of the inside shell of the belemnite type, have together disappeared in the limy plate or "cuttle-bone" of sepia and its allies—a rudiment of its chambered portion being indeed still recognisable in its so-called "mucro," and we have thus left to us in the sepia, merely the rudiments of the belemnite's "chambers" and "guard." The horny "pen" of the squid represents a still more modified structure on which the laws of development have operated, modifying and deleting the shell-rudiment until it remains merely as an interesting landmark in the evolution of its possessors.

Thus the history of the cuttlefish shell forms an important chapter

in the biography of the race. The rudimental shells of the two-gilled cuttlefishes, like the teeth which never cut the gum in unborn whales, have a reference not to their present life, but to a former state of things. Contemplating the "pen" or "cuttle-bone" of a modern squid or sepia, our thoughts become moulded in mental continuity with the past. There rise to view before our mind's eye the ancient nautili and their sculptured kith and kin the ammonites, crowding the sea-beds of the far back Mesozoic, and still more remote Palæozoic ages. Then, through the operation of the inevitable laws of organic progress and advance—making the ancient world then, as they constitute our world to-day, the theatre of continual change—we see the two-gilled stock arise in Secondary times from the four-gilled race. First there is seen the modification of shell. Concurrently with the decrease of shell comes increase of head-development and elaboration of nerve-centres, tending to make the new two-gilled form what we know it to be to-day—the wary, watchful organism, living in the waters above, and occupying a sphere of vital activity immeasurably superior to the dull existence passed by its four-gilled ancestors on the ocean bed. The shell degenerates more and more as the cuttle-fish race rises on its own branch of the animal tree. Development in numbers succeeds individual advance. The cephalopod tribes of the present time dawn fuller and fuller as the Tertiary period progresses. Thus the fulness of cuttlefish life to-day, exhibited in all its strange weirdness, is interwoven, like the lines of human history itself, with the warp and woof of the past. And not the least important clue to the history of that past is found in the apparently insignificant "shell" we have discussed; since in its mere degeneracy, it leads us backwards in an instructive glance to those early times when the chief branches on life's tree had not reached their full fruition, and to the days when the world itself was young.

VI.

THE MIGRATION OF ANIMALS.

THE peculiar instincts which lead certain kinds of animals, and most notably certain groups of birds, to leave one country or region and to pass to another on the arrival of certain seasons, has long formed one of the best known facts of the natural history knowledge of ordinary life. The migratory habits of animals, indeed, could hardly escape the notice of even the most casual observer of the phenomena of life at large ; and it is not surprising to find the accuracy of ancient zoologists and philosophers well exemplified in the chronicles they have left us regarding the seasons of migration of the birds with which they were best acquainted. The " appointed times " of birds were a subject of remark with observers even before the era of the classic naturalists ; and on the regularity with which certain species appeared and disappeared, a very natural argument respecting the wisdom which presides over and regulates natural phenomena was founded. As our knowledge of other groups of animals advanced, the habit of migration was seen to be represented in fishes, in insects, and in other classes of lower animals, and amongst mammals or quadrupeds as well. The habits of birds, however, naturally attracted the largest share of attention, because of their conspicuous nature ; and, indeed, the explanation of migration and its causes is chiefly drawn from what has been observed regarding migrating birds and " the time of their coming." The interest attaching to this subject has, moreover, largely increased within recent years, from the relationship it possesses to the alteration of the physical universe around us. Cases of migration and instances of the alteration of land surfaces become mutually explanatory, as we shall endeavour presently to show ; and a study in natural history may thus be shown to relate itself in a very important fashion to matters of the deepest interest to all who recognise in the history of our universe and its living beings a legitimate and absorbing theme for thought.

Some of the more prominent cases of migration in animals may be first glanced at, by way of preliminary to the discussion of the nature and causes of the instincts which prompt this curious habit. There appears to be little doubt that the habit is possessed by certain kinds of insects, although, obviously, the exact nature of the journeyings of these animals is more difficult of determination than that of

the migrations of higher forms of life. The swarms of locusts which from time to time visit regions in which they are total or comparative strangers, probably follow some law or habit of the kind under consideration. Travellers have placed on record the interesting fact that hordes of butterflies occasionally pass from one district or region to another; this insect stream, numbering its gaudy members by thousands, pursuing its course for days without cessation. In such a case, the cause of migration is utterly unknown; and, as in other cases of animal journeyings, the somewhat irregular and erratic nature of the habit only tends to render its elucidation the more difficult. The little beetles well known under the name of ladybirds, valued by the gardener as the enemies of the plant-lice, are known occasionally to appear in some districts in immense swarms, and to disappear as suddenly and as mysteriously as they appear. Regarding the journeyings of insects from one country or region to another there is an obvious difficulty of accounting for their movements when we consider that neither considerations connected with food and its scarcity, the breeding habits of the animals, or other conditions of life, will account for their migration. Probably it might be the more warrantable course to regard such journeyings as accidental to a large extent, and as therefore partaking less of the true nature of migration than instances where a regular and periodically recurring journey is made from one country to another.

Cases of migration which have been, and still are, determined by the recurrence of the breeding season and reproductive habits of the animals concerned, are exemplified by certain fishes. Of these the salmon and herring are the best known, but the list might be augmented by the addition of the mackerel, pilchards, cod, and other of our food-fishes. The migrations of the salmon are thus perfectly ascertained to correspond not merely with its gradual growth towards maturity, but with the deposition of its ova or eggs. These fishes ascend rivers to spawn, and then migrate once more to the sea. They alternate in this way between fresh and salt water, not merely during adult life, but also during their earlier stages of existence. As the "parr," or form in which it leaves the egg, the young salmon inhabits fresh water; whilst as the silvery "smolt," which succeeds the parr-epoch, it seeks the sea. So thoroughly necessary for the growth and life of the smolt is the seaward migration, that the "grilse" stage, or subsequent epoch of salmon-growth, is completely delayed unless the smolt is allowed to pass to the briny deep; whilst the "parr," on the other hand, languishes and dies if placed in sea water. Rapid growth succeeds the seaward journey; the fish migrating, as the "grilse," to fresh water to spawn, and year by year repeating this latter journey as the salmon. That such migration is something more than a casual habit appears to be proved by the fact

that the salmon rarely, if ever, feeds whilst in the rivers—a case of abstemiousness from food apparently paralleled by that of the fur seals, which are currently believed to abstain from food during their breeding season—a period extending over three months. The skill of the salmon-fisher, indeed, is taxed by the care with which he has to prepare the bait for the fishes whilst they inhabit the rivers, and the remarkable habit of voluntarily depriving themselves of food, correlates itself in a very singular fashion to the instinct which primarily leads the salmon to seek a change of abode.

The migration of birds introduces us to instances of habit, not only of regular and definite kind, but which moreover present a basis for the exercise of that reasonable speculation which in its most valued aspect leads us towards an appreciation of the "causes of things." The periodical and for the most part regularly-timed flights and disappearance of many birds from one land to another, were noticed by the early observers of natural phenomena. So marvellous, indeed, did the disappearance of many birds appear to their minds, that theories which accounted for their absence on the idea of their lying torpid at the bottom of lakes, or within the kindly shelter of caves, were gravely discussed. And amongst the thoughts concerning the causes of the flights of birds which were ventilated, may be mentioned that of the Scandinavian poet, who maintained that they migrated in the search for "light." However poetic the fancy that birds sought "more light" may be, it is unfortunately dispelled by a reference, not merely to the facts of migration, but to those connected with the ordinary variation and changes of the seasons. The southward flight of many birds begins, or may even be ended, before the autumnal equinox; the migrants in such a case actually flying towards shorter days than towards "more light." Similarly, many birds fly northwards before the spring equinox, and thus find themselves in a land of shorter days and "less light." Temperature is no doubt a very prominent and important condition for consideration in connection with migration; but this subject has to be regarded in the light of other conditions, and in any case is but one cause amongst many others which have operated in producing and perpetuating the habits under discussion.

The cuckoo is probably one of the most curious of migratory birds, as well as one of the most familiar. It presents the well-known habit of depositing its eggs in the nest of another bird, and departs immediately, after it has thus secured foster-parents for its young. Northern Africa appears to be the principal home-centre of the cuckoo, and from its Ethiopian residence it flies northward to Britain in March or April. Some three months altogether are spent in the north, and the cuckoo then flies southwards in the early autumn to its African home. This bird, it must be noted, deposits its

eggs, at short intervals, in different nests, and the young are thus born at different periods, a circumstance which favours the unimpeded home-flight of the birds. The swallows and swifts are migratory birds of world-wide fame. The swallows arrive in Britain at the end of March or beginning of April, and appear to cross the Channel either singly or in small groups. Two broods are produced in each year by the swallow, and it has been occasionally observed that the young of the second brood have been left to perish, owing to their immature state when the period for flying southward arrived, the migratory instinct thus overruling the parental affection of the birds. The swifts arrive in Britain at the end of April, leaving their home in Northern Africa at a period when a genial climate prevails, and when their insect food is plentiful. By the end of May the young are hatched, and at the beginning of July parents and progeny are circling rapidly in their graceful evolutions, as if preparing for their southward flight, which occurs shortly after the date just named. Amongst our common and smaller birds which present us with more or less typical examples of migration are the skylarks, redbreasts, song thrushes, blackbirds, and many other birds not usually regarded as migrants. It is a well-ascertained fact, however, that these birds fly southwards to the shores of the Mediterranean Sea and to Southern Europe generally in winter, and the causes of their southward movements are by no means clear, if we consider that the conditions of existence in Britain during winter are by no means of hard or unbearable nature to such species. The quails present examples of migrants belonging to a group of birds widely different from those which include the examples just mentioned. These birds leave the North African and Mediterranean coasts in spring, and fly to Europe in large numbers ; their plump condition at the migratory period forming a quality of disadvantageous character to the species, on which a constant war is made in the interests of gastronomy at large.

Amongst more peculiar features in connection with the migration of birds may be mentioned the attachment which many species exhibit for their former habitations. Swallows are known to dwell year by year in the same places, and the water-wagtail will select the same spot annually for its nest. An instance is related of such attachment being exemplified by two stone curlews (*Œdicnemus crepitans*)—a species of bird inhabiting the open country—which year by year repaired to the same nest, and this, although the character of the surroundings had become entirely altered. The nest had originally been situated in a rabbit warren, and in the lapse of years the warren had been gradually replaced by a flourishing plantation of young trees ; the curlews, however, remaining steadfast to their annual quarters, despite the altered character of their home. The

fact that many birds will repair year by year to the same spot is of extreme interest, if we consider that the migratory habits must have yearly led them on journeys of many hundreds or thousands of miles in extent from their British nests. The possession of a very decided and definite faculty of "locality" is thus apparently possessed by many birds. In virtue of this faculty, and the memory and affection they retain for their habitations, such migrants will fly unerringly from the Mediterranean coasts to the northern parts of our land or of Europe at large; or may even rest in their old homes after a flight which had its beginning in regions lying beyond the equator. Dr. Jenner's well-known experiment on the swifts fully confirms the accuracy of the ideas regarding the return of migrants to their old resting-places. The famous physician having procured several Gloucestershire swifts, cut two claws from a foot of each specimen, and thereafter liberated the marked birds. The nests were examined annually, and for three successive years the marked swifts were found each in its own nest; one of the marked specimens being actually found in its accustomed locality after a lapse of seven years. Even if it should be suggested that it is difficult or impossible to identify the birds of each successive year as the veritable occupants of the nest during the preceding years, or that possibly the birds arriving each year to occupy a given nest were different individuals of the same species, the circumstances become more puzzling and extraordinary on account of these very suggestions. For then we should have to explain how birds communicate with each other, and the nature of the mysterious bond which would thus be presumed to link together the different individuals in an affection for a particular home. Even on the supposition that the young in course of time might occupy the nest of their parents, we should also have to postulate a wonderful accuracy of instinct and a tenacious memory of locality.

In connection with such instances of memory and affection for particular localities, we must take into account the distances over which birds have to travel—a feature casually alluded to in the preceding remarks. It is also worthy of note that the extreme length and magnitude of the journeys of many migrants bear an important relation to the nature and causes of the migratory habit. The idea of a simple adaptation to surrounding conditions would fully explain the migratory habits of animals, did we find that they moved backwards and forwards within a limited area, and according as the seasons and food were respectively favourable and plentiful. But so far is this from the true state of matters, that one of the chief puzzles of the zoologist is to account for the apparently needless extent and magnitude of the journeys of many migrants, their change of area being inexplicable, as already noted, on the supposition of seeking a genial temperature or a favourable feeding-ground alone.

No consideration of the latter nature, for instance, would satisfactorily explain why swallows or swifts should leave the genial climate of Northern Africa for the less genial north, at a period when their insect food is as plentiful, if not more abundant, at home than in Europe. The ruby-throat, one of the prettiest and smallest of the humming-birds, flies annually from Mexico to Newfoundland, as a summer migrant to the south. It thus apparently exchanges a land of plenty for a comparatively unsatisfying Egypt, and in its extensive flight certainly passes over lands better suited for its support than the terminal area in which it rests. One of the most interesting points in connection with the migration of birds naturally consists in the determination of the rate or speed at which the migrants fly. On the whole, surprising results may be said to follow the most cursory inquiry into this subject. The common swift is said to wing its flight at the rate of some 275 miles per hour; a speed which, if maintained for six or seven hours, would suffice to transport it from its summer to its winter quarters, or *vice versâ*. The speed of the swallow is said to average ninety miles per hour, and the famous passenger pigeon of America can make its thousand miles per day with ease. Of this latter bird it is recorded that pigeons have been killed near New York having their crops filled with rice, the nearest rice-fields to New York being those of Carolina and Georgia. These fields are distant between 300 and 400 miles, and as digestion is tolerably rapid in the pigeons, six hours may be regarded as a fair average period for food to leave the crop. Within six hours, it may therefore be calculated, these birds must have flown the distance between New York and the rice-fields, the rate of speed being equal to that of an express train.

The carrier-pigeons are equally notable for their speed, and for the unerring accuracy with which they return to their haunts: this latter faculty being apparently a special modification of that whereby migrants return to their summer and winter quarters, and depending, firstly, upon a knowledge of landmarks or some mysterious "flight-faculty;" and, secondly, upon the faculty of memory and locality. A carrier-pigeon has been known to fly from Rouen to Ghent—a distance, "as the crow flies," of 150 miles—in an hour and a half. Recently a pigeon flown from the window of the Continental mail train as it left Dover pier, was found in its home in the City long before the arrival of the train in London. From the "Country" we extract the following details of a remarkable pigeon-flight from Reading, Berkshire, to Brussels, a distance of 238 miles. In July 1878, Mr. Barker, of Brussels, sent to Reading some young pigeons, accompanied by five adults, the latter being intended to fly back to Belgium. The birds arrived in Reading at midday on Thursday, the 25th of July, and were duly inspected by many of the

members of the local Ornithological Society, each bird being duly marked with the Society's official stamp. On Friday morning at ten o'clock, says the account from which we quote, in favourable weather, the five birds were started. They dashed from the basket without hesitation, and disappeared from sight in about one minute. A telegram was received in Reading the same evening, announcing that all the birds had reached home before four o'clock, the information also remarking the official marks of the Reading Society, by way of sure identification of the pigeons. Three of the five birds, it may be mentioned, belonged to Mr. Barker, and two to a friend. The latter were found in their loft at Brussels shortly after half-past three o'clock; Mr. Barker, on reaching home a little before four o'clock, finding his three pigeons there. The birds were feeding quietly, as if they had been reposing at home throughout the day. The account adds that the pigeons in question had "done a lot of work in other directions," but that their only journey before being sent to Reading was one "toss" of about forty miles in extent. Allowing fifteen minutes for difference of time, the duration of the flight from Reading to Brussels was five hours fifteen minutes, the flight being at the rate of 1,329 yards per minute.

The instincts or faculties in virtue of which birds are enabled to fly over many hundreds of miles of land and sea, naturally bear the closest possible relationship to the habit and means of migration. What explanation can be given of the wondrous powers of guiding flight possessed by birds at large; and through what special sense or senses is the "flight-faculty" exercised? Any attempt which may be made towards the solution of these questions may fitly be prefaced by a confession of our almost complete ignorance of the means whereby extensive flights alluded to are directed. A high authority on matters ornithological has remarked that we are unable even to approach the solution of the question. Carrier-pigeons possess the "homing" faculty, as it has been termed, in a typical degree, but when inquiry is made regarding the nature of this faculty, the answer that these birds are guided by a knowledge of landmarks is made. Admitting, however, that the "homing" faculty is so founded, the admission demands the exercise of a sense of sight keener far than that possessed by ordinary animals, and of a memory for locality which almost excels our ideas of instinct as distinguished from reason—although, indeed, there are not wanting numerous examples of a "memory sense" in dogs, which find their way back to their homes, and by paths unknown to them, with an instinct which may be described as literally unerring. But the "homing" faculty of the pigeon, resting, as is maintained, on a knowledge of landmarks, will hardly suffice to explain the flight of birds over large tracts of sea where guiding marks are non-existent. Then, again, many birds

pursue their journeys by night, when the sense of sight is either practically unavailing, or may be regarded as being of comparatively little use. The discussion of this subject may only be profitably carried on in the light of higher knowledge; but, as will presently be noted, the consideration of the determining causes of migration leads us to believe that the unerring flight of migratory birds, as well as the exactitude of their arrival in their summer home, and of their departure for their winter haunts, are regulated by the force of long continued "habit," and by the influences of "inherited instinct."

No two factors are of greater import, or exercise a more despotic power over the fortunes of lower life, than "habit" and "instinct." By their aid animals accomplish unerringly, and it may be unconsciously, acts and labours which the educated experience of human kind would perform but imperfectly, in which experience would altogether fail. Witness in proof of this statement the perfection of the acts and duties in which the bee, wasp, or ant engages from the first moment of existence. The very perfection of the act as performed by these unreasoning creatures is, as Dr. Carpenter has remarked, a proof of the non-intelligent and purely instinctive nature of the beings which perform it. Otherwise, indeed, the perfection of their labours must be held to surpass that attained by the human reasoner. And so is it, we opine, with birds, with the guidance of their flight, and with the exactitude of their seasons. Admit the influence of inherited habit, and we find a mysterious power of guidance supplied by instinct to the migrating bird, just as the young worker-ant, liberated from its swaddling-clothes, proceeds, without any training other than the directive force of instinct and habit inherited from its predecessors and progenitors, to discharge its duties with the punctuality and perfection of the mature and adult insect. How the habits which instinct directs, and which heredity, or the law of "like parent, like child," propagates, have been acquired is a matter for after consideration. Once, however, admit the acquirement of the habit, and its continued performance by the species, and the laws of descent and likeness will accomplish the rest. It is true that a wider range of senses and faculties than that of which physiologists are as yet cognisant in man, may be the property of many of the lower animals. Sight and memory in their special phases of development—as applied to the guidance of a carrier-pigeon, for example—must be of a character much more acute and strong than we are accustomed to regard these faculties as represented in human existence. And if to acute senses we add the idea of the unconscious, but unerring, direction of instinct and habit, strengthened by transmission through extended epochs of time, we may perchance discover a rational means of approaching the solution of the mystery whereby the bird

directs its way in the air, and passes unerringly to its destination through the illimitable azure.

Allusion has been already made to the exactitude with which migratory birds may arrive and depart from any given region, and this punctuality has been cited in support of the exact regulation, through instinct and habit, of the life of the birds. A bird almanac might, indeed, be constructed through the observation of the "appointed times" of certain species, on the principle of constructing a "floral clock" by watching the times of the opening and closing of flowers. The vast majority of the migratory sea-birds and waterfowl arrive punctually to a day on our coasts from the far north. Amongst such birds none appear with greater exactitude than the puffins; and despite contrary winds and delaying storms, many allied species of sea-birds arrive at their particular stations with almost clockwork regularity. So also the periods of return to their foreign quarters, or of departure from our shores, appear to be fixed and adhered to with an undeviating punctuality which bespeaks a regulation by unconscious instinct and automatic will. That the periods of departure from our shores are in particular regulated by the influence of such unconscious habit and inherited instinct is clearly proved by two very notable circumstances, calculated to attract the notice alike of the reflecting naturalist and of the unskilled observer of birds and their history. The first of these circumstances has already been referred to in the case of the swallows, the migratory instinct in which is so strong, that the unfledged young contained in the nest when the day of departure arrives have been left to die by the retreat of their parents. In such a case a more powerful incentive—that of inherited and obdurate instinct—has triumphed over parental affection itself. Then, also, a curious and perhaps more notable feature of bird life than the preceding circumstance is found in the fact that the caged young of migratory birds exhibit a decided restlessness at the period of migration when their free neighbours are leaving our shores. Such confined migrants, which themselves have never migrated, will beat their wings against the bars of their cages, and will show by every symptom and indication that they participate, by nature and instinct, in the movement of migration, of which they have had no previous experience of any kind. This latter fact is in itself a powerful argument in favour of the idea that true migration is in itself instinctive and acquired by heredity; and the fact tells also in favour of the acquirement and perpetuation of the migratory habit under circumstances to be presently detailed.

The manner in which migration is performed varies with the group of birds which exemplifies the habit. The best example of a bird which leaves Britain *en masse* is the swallow, whilst the cranes,

storks, wild ducks, wild geese, and many other species also migrate in bands. The cranes and stalks fly in a vast triangular cloud, guided by a leader, who retires periodically, and whose place is successively filled by other members of the band. Of birds which present peculiarities in their mode of journeying, the skylarks may be cited. These latter birds arrive on the Norwegian coast in "a straggling stream" at first, whilst a little later enormous flocks appear. In the case of many species of birds flying northwards in spring, the males are the first to arrive, and precede the females by several days, or, it may be, by several weeks. Such a peculiarity is not noticeable in the southward migration taking place in autumn. It is likewise interesting to note that many birds appear to wait for "favouring gales." The quails select a favourable wind for their flight, although it happens that these birds are annually drowned in large numbers in the passage of the Mediterranean Sea. This sea is, in truth, the great Rubicon of the migrants. It is crossed, by way of Greece and Cyprus, at Sicily, at Malta, or from the South of Spain. By crossing at these points, land is necessarily kept more or less constantly in sight. The young birds of each year frequently migrate alone, their parents having preceded them in their southward flight. It is a well-ascertained fact that the young of some birds which spend the colder season in the North of Africa may pass the first winter of their lives in the South of Europe—this latter feature presenting us thus with probably a recent modification of the migratory habits of the species. The old birds lead the way in cases where the young brood accompany their parents to the warm and autumnal residence. We may lastly note that migratory habits, as just remarked, are themselves susceptible of modification. Although human observation serves but as a "brief chronicle" of a brief time, we yet know sufficient of the alteration of the habits of certain species of birds to warrant the assumption that, under favourable conditions, the journeyings and range of habitat of birds may be altered. Mr. A. R. Wallace cites a typical instance of this kind in the case of a Mexican swallow. This bird first appeared in Ohio in 1815. Its range of habitat gradually increased in extent, since the year 1845 found this bird in Maine and Canada; whilst at present it is found as far north as Hudson's Bay. The cliff swallow of North America is regarded as having extended its distribution eastwards from the Rocky Mountains to the eastern coast of the continent within the past century or so. Similarly a species of wren has extended its range northwards in America in past years; and the rice-bird, originally confined to a few districts, has extended its range of distribution as its food was more widely cultivated, and is now found wherever rice is grown.

The facts relating to migration which occupy the preceding part of this article may be regarded merely as a somewhat extended

introduction to the question, "How have migratory habits been inaugurated and perpetuated in birds?" It is needless to say that any answer which can be given to this query must be speculative in its nature. No direct evidence of the beginning of this habit in any animal is at hand, nor, from the very nature of the case, can such testimony be procurable. Hence we have to correlate facts, to marshal them in relation to one another, and to string them together by aid of generalisation and theory. Such is the true relation of theory to fact—a relationship which not only permits but demands, firstly, the correspondence of facts and their connecting hypothesis; and, secondly, the ability and desire to modify the theory according as new facts or higher interpretations dawn upon us. One or two features in the case of birds seem in some degree to aid us in forming a natural theory of migration. This habit, it should be remembered, occurs in very varied and different groups of birds. Species, genera, and families widely separated in structure, food, and habits, exhibit the like instinct of periodically passing from one country to another at certain seasons. Through such a fact the zoologist points out that migration is an acquired habit, and not one originaliy or from the first affecting uniformly great groups or large classes of birds.

The observation that widely separated birds exhibit the same habit further warrants the inference that the varied species have acquired migratory habits through exposure to *like conditions*. Now, what were these "conditions"? Suppose that, as in America, a species of bird was presented with a continuous land surface running north and south. Such a bird, subjected, it might be, to increasing cold from the north, would pass easily and readily southwards. An alteration of the temperature in favour of a more genial climate, and the retreat of the cold, would be followed, on the other hand, by the northward return of the birds. If we suppose the bird to have been an insect-feeder, the case is presented still more feasibly to view, inasmuch as the failure of the food supply from cold, and its revival during the returning heat and geniality of climate, would constitute a sufficiently powerful incentive to migrate southwards, and an equally powerful inducement to the northward return. But is this case of alternation of hot and cold epochs, or of cold with genial climates, anything more than supposition? The geologist's reply bears that in comparatively "recent" times, and in the Miocene period, Europe, and the northern parts of the world generally, possessed a climate which, if not exactly tropical, was the reverse of rigorous. Succeeding the genial Miocene epoch, with its subtropical flora and fauna, the great ice age slowly but surely dawned, blighting the plants which had formerly flourished in plenty beneath a kindly sun, covering hill and dale with a great ice-sheet, and filling the valleys with its

glaciers and snows. Geology has no historical or absolute chronology, and the duration of the ice age may not be set down in years. That it was a period of extensive duration, however, there is no reason to doubt, and when it passed away it was succeeded in due time by the temperate climate we now enjoy. The effect such alterations of climate would have upon animal life may readily be conceived. Retreat from north to south, as the ice age advanced its chilly snow-sheet, would be the order of the day, and the extent of the southward journeying would be determined conjointly by the rate of advance of the ice-fields and by the failure of food. The renewal of the genial climate would result in the northward journeying of the birds, which, having become accustomed through long ages to a larger area of habitation, would naturally journey to and fro within that area—a region of habitation in the case of our own migratory birds extending from the North of Europe to Central Africa, and possibly further south still. Geology, it is true, does not prove much to us from the fossil history of birds, for the remains of birds are few and far between as compared with those of most other animals. But if quadrupeds once denizens of European forests are now extinct therein, and are found represented by living species only in southern and warmer areas, we may readily enough conceive that birds would similarly be driven southwards, and with greater powers of movement and of dispersion by flight would more readily seek and regain their ancient home when the genial climate of to-day succeeded the ice age of the geological yesterday.

Nor is this all. The instinct which prompts and directs birds to fly from one land to another may be thus regarded as being inaugurated by the alternation of cold and warm climates, and as having been inherited and promulgated in some birds, and altered or extinguished in others. We may, however, learn from geology the plain reason why this instinct had, so to speak, an easier task before it at the beginning of the habit of migration than apparently lies before it now. Before, during, and after the ice age, the boasted independence of Britain, as far as its isolation from other lands is concerned, had no status or existence. Britain was then part of the European continent, and although the broad basin of the Mediterranean was probably sketched out, Europe and Africa were one, and were locked together by connecting land. With succeeding years, however, subsidence of land had done its work, and had broken up Europe in the north, and dissociated Ethiopia from Europe in the south. The birds, however, began their migrations over continuous land surfaces, such as exist in the New World of to-day, and the habit and instinct of flight overland thus came to serve the turn of the animal when that land was here and there broken up and when the deep rolled over the sunken world. The instinct acquired in the

former land flights is thus seen to operate in the after ages as an unerring guide over the changed aspect of affairs, and to lead the migrants safely and securely over the pathless deep. In the case of the carrier-pigeons we probably witness a high development of the same instinct, associated with a special faculty of memory and with a wondrous perfection of sight.

Inherited habits, induced by changes of food, and these latter in turn produced by alterations in climate and accompanied by changes in the distribution of land and sea, are thus noted to constitute the factors in inaugurating the habit of migration. It seems admissible, however, to suggest, by way of conclusion, the fashion in which another and different set of circumstances in the life of birds might give rise to the adoption of migratory habits, and cause a species to assume a place in the list of migrants. Let us imagine a number of birds to be carried—as some species not unfrequently are—by contrary winds into an area differing as widely in climate from their native haunts as Britain does from Northern Africa. The result to the birds, should such an event happen in winter, would be of the most untoward description; but if the northward and forced flight were taken in summer, the birds finding abundance of insect-fare in Britain, might find in the latter fact, and in the genial climate, an inducement to prolong their visit. Imagine, further, that the breeding season of these birds arrived in due course—an event which the plentifulness of food might and probably would expedite—and we should find the young to be born in the new land; the production of more than one brood (as in the swallows) being determined probably by the amount of food and the continued geniality of the climate.

The fact of the young being reared in any particular locality possesses of itself a sufficient and powerful effect in inducing a close association between the bird and the locality. Hence the production of the young in the new home would unquestionably tend to impress the birds in favour of the new locality. The returning cold of autumn and the scarcity of insect food would serve as a sufficient cause accounting for the southward migration. And if to the condition of temperature we add the consideration that land may have prevailed where the Mediterranean Sea now exists, the original home of the birds might readily enough be found. Admitting, as before, that of the "finding instinct" of birds we know literally nothing, the idea of a continuous land surface is geologically both possible and probable. The arrival of the young brood, led by their elders, in Africa, would conclude the preliminary conditions for the establishment of the migratory propensity. Then comes the consideration of the *force of habit* and *instinct*. The instinct of having bred in the northern land would serve as a sufficient incentive on the

part of the old birds to cause them to leave their native area once again, and this time as willing emigrants. Not less strong would be the instinct of the young brought up in the north, and thus with the returning season of spring the birds would fly northwards, and repeat the procedure of the previous year. Admitting these circumstances and the undeniable force of habit, the theory that migration is the strengthening of a chance and favourable association with a new land becomes of likely and feasible kind. That young birds which have *never migrated* participate by nature and instinct in the migratory tendencies of their parents is proved by one of the most extraordinary facts already mentioned in connection with this subject—namely, that caged birds of a migratory species become restless, flap their wings against the cage, and exhibit every sign of excitement at the time when their free neighbours are flying homewards. And this being so, the idea that the instinct of the first emigrants of a species would be sufficient to guide them to their new home after a sojourn in the native area of their species, is rendered by no means improbable.

The migrations of animals is thus seen to be a subject which relates itself to the geographical distribution of living beings on the one hand, and to the geological or past history of our globe on the other. It also concerns the acquirement of new habits, and the modification of the old habits of a species, and is thus calculated to teach us some valuable truths concerning the modification of the ways of life at large. To the more evident bearings of the subject on the geographical distribution of animals and on geological change we will return in a succeeding chapter. The present topic is, however, not the least worthy or interesting of the lessons regarding our universe which Nature, from her outspread pages, is continually inviting us to peruse.

VII.

THE PROBLEMS OF DISTRIBUTION AND THEIR SOLUTION.

PERSONS whose acquaintance with the methods of biological study cannot be regarded as either extensive or profound, may nevertheless regard themselves as perfectly capable of detailing exactly and succinctly the four chief points involved in the consideration of any living being. The history of an animal or plant, however superficially that history may be viewed, presents a series of problems which it is the business of the biologist to solve. These problems resolve themselves sooner or later into four questions, the replies to which, if given in full detail, supply us with a perfect knowledge of the present and past life of the organism and its race. Query the first, concerning the living being—animal or plant, monad or man—resolves itself into the inquiry, "What is it?" To this question the science of *morphology*, or that of *structure*, affords a reply. The external form and the internal anatomy of the organism are investigated under this primary question of the biologist. The animal mechanism and the nature and relations of plant-tissues and organs fall naturally within the scope of this question and its reply. But the organism possesses its vital activities as well as its structural details. In the essence of its nature, it presents for our study those actions through which it maintains its own individual existence, and that of its race or species likewise.

A second question thus becomes imperative, and inquires, "How does it live?" To this query it is the province of *physiology*, as the science of *functions*, to reply. Summarising the life of any organism, three terms may be found to denote the sum total of its vital activity. It firstly nourishes itself, and thus engages in the exercise of the function of *nutrition*. It thuswise provides for the maintenance of its individual frame. But as the death of individuals thins out the ranks of the species, the exercise of a second function, that of *reproduction*, provides for the continuance of the race in time. Then, lastly, the animal or plant, whatever its sphere or place in the organic series, or in the world at large, exhibits certain relations to its surroundings. Deprived of the means for exhibiting this relationship, the living being becomes practically as the dead things around it. It is the power of relating

itself to its environments which gives to the living body its chief characteristics. It is the action and reaction of the organism upon the world around it, and its adaptation to its surroundings, which impart to the animal or plant its plainest differences from the inorganic things around. Hence we distinguish a third function of the living being; that of *innervation* or *relation*. Exercised through the medium of a nervous system or its representative tissues, this function of relation regulates and controls, whilst it connects and harmonises, the other actions of which life's activities consist. The animal or plant, regarded from a physiological standpoint, lives thus a threefold existence, and performs a triple round of duties. It nourishes itself, it reproduces its race, and it develops and exhibits relations with its surroundings. The knowledge which demonstrates how these functions are performed answers the second of our four questions—"How does it live?"

Structure and functions, all-important as their detail may be for the understanding of animal and plant histories, do not, however, constitute or bound the entire range of biological observation. The inquiries of even the childish stage of man's culture concerning the living as well as the non-living universe, include, above all other points, the inquiry, "Where is it found?" Especially natural does such a question appear when applied to the living tenants of the globe. When we ask ourselves where any organism is found, in what quarter of the globe it is plentiful, where it is scarce, or where, lastly, it is never to be discovered, we are in reality approaching topics which lead us tolerably near to the ultimate questions of all biological study. It is the science of *distribution* which professes to answer the questions relating to the whereabouts of animals and plants in the world as it now exists, and in anterior epochs of our globe as well. Distribution thus includes two most natural divisions or lines of inquiry. It summarises the existing life of the globe in its inquiries regarding the geography of living things, or their *distribution in space*, as it is technically termed; whilst it no less succinctly attempts the solution of the problems relating to the past history of animals and plants, when, proceeding to avail itself of the information collected by geology, it pictures for us *their distribution in time*.

The knowledge of the structure, functions, and distribution of a living being once comprehended all that science could hope to know of its history. Contenting itself with the fact that living beings are, biology might regard the knowledge which these three queries, "what," "how," and "where," supplied, as all-sufficient for the furthest mental demands. But the newer epoch of biology includes a fourth question in its list of queries concerning living things. It presents for solution yet another problem, in the terms of which is focussed all the knowledge gained in other departments of biological

research. This fourth query is that which demands to know "how the living being has come to be what it now is"—or "how it has attained to its present place and position in the animal or plant series." The mere terms of such a question presuppose that the living population of our globe has undergone progressive development. It postulates change and alteration as natural conditions of existence, and it inquires how, in the case of each animal or plant, such change has operated—in what direction it has sped, and how it has affected and modified the living organism. Thus stated, there can be no difficulty in recognising the theory of evolution or development as that which purports to supply this mental demand, and to reply to the inquiry concerning the past history of animals and plants in relation to their present position and genealogical connections. Time was when the need for such a question was non-existent. So long as mankind regarded the world of life as presenting a fixity of constitution, there could exist no question of wide organic change for the biologist to meet and answer. With a firm and undisturbed belief in the special and independent "creation" of each species of living beings, the mind could experience no philosophic or other necessity for any inquiry into a past of modification and change. Possessing the idea that stability of organisation and form was the rule of existence, men had not learned to look for a past wherein, as in a glass darkly, might be discerned the birth of new species arising through the modification of the old. But the germ idea of such an evolution of life existed and prevailed long before the age which has seen its full fruition. Here and there evidence is to be found that even in classic ages, the great problem of problems concerning the how and why of the universe itself was growing apace in the minds of men. Aristotle, remarking that rain falls not to make the corn grow, any more than it descends to spoil the crops, asks, "What therefore hinders the different parts (of the body) from having this merely accidental relation in nature?" So also Lucretius, in another department of inquiry, shadowed forth the atomic constitution of things, and paved the way for the thoughts of the after ages, when Lamarck, Erasmus Darwin, Goethe, and, in our own day, Charles Darwin, Wallace, and others, have busied themselves with the problems of the development of the teeming population of the globe. Thus arises the philosophic necessity for a fourth question—that of the *ætiology* or causation of living beings. This question, utilising all the knowledge gained by the sciences of structure, physiology, and distribution, endeavours to show how the organic world has grown and progressed towards the perfection it exhibits before our waiting eyes to-day.

This brief sketch of the four great questions of biology may serve to show the exact position which the study of Distribution

bears to the other departments of natural-history research. Taking its stand as a distinct branch of inquiry; dealing with the causes which have placed animals and plants in their distinct regions; investigating the conditions which make for or contend against the diffusion of animals and plants on the surface of the globe—the science of distribution presents problems and attempts the solution of questions involving, it may be, the furthest knowledge of present and past alike, which is at our command. Nor must we neglect to note that the study of distribution relates that present history, in the most intimate fashion, with the past of the globe. The continuity of the past with the present is too much a ruling idea of the biological mind to allow the importance of the geological factors in the world's problems to be overlooked. Not a few of the knotty points of distribution are soluble from the side of geology alone. If, therefore, for no other reason than that it links present and past so intimately together, thus making the unbroken continuity of causation a necessity in biological explanation, the study of distribution would take its place in the first rank of the sciences of to-day. Bearing in mind this twofold division of distribution into that *in space* (or "geographical distribution") and that *in time* (or "geological distribution"), we may now profitably proceed to inquire into the history of the growth and progress of this department of inquiry.

If we turn to text-books on natural history, written even some ten years ago, we shall discover that, whatever may be the importance of the study, the science of distribution is of comparatively recent growth. The information dispensed in these manuals of biology resolves itself for the most part into a brief recital of the countries in which different animals and plants are found. Thus the facts of distribution, which an intelligent child is now taught in the nursery, comprehend all that was known, even in recent science, respecting the habitats of animals and plants. To know that lions occur in Africa, and tigers in India; to learn that the giraffe and the hippopotamus are tenants of Ethiopia, and that rhinoceroses occur both in Asia and Africa; to be able to say definitely that kangaroos never occur without the bounds of Australian islands, or that humming-birds are found in the New World alone; to know where palms grow or where cacti abound—these were the only facts which the "distribution" of twenty years ago included. The plain enumeration of these or any other facts, however, does not raise them to the rank of a science. The mere mention of the detached countries in which plants and animals occur, does not constitute a philosophical piece of information calculated to explain either itself or any correlated facts of natural history. That method alone converts any body of details into a science, which places them in harmony with each other, and which, connecting them by, it may be, even a transcen-

dental bond, links them together as parts of a whole. To know, for example, that the existing horse walks upon the greatly developed third toe of each foot, to become aware that the horse likewise possesses two rudimentary toes on each foot, are mere facts, valuable enough perhaps in themselves, but useless, so long as they remain isolated, for any higher or philosophical reasoning concerning the horse or any other animal form. Once, however, let these facts be placed in true harmony with other details regarding the equine race, and the science—that is, the true knowledge—of horses is then constituted. Thus, if we discover that the horses of the present are connected by a complete series of gradations with the horses of the past; and that we may pass by graduated stages from the one-toed horse of to-day to the five-toed Mesozoic ancestors of the race, we at once rise into the region of a philosophy which, through correlated facts, seeks to teach us the origin of the equine species. If, further, knowing that horses were believed to have first been introduced into the New World at the Mexican Conquest, we suppose that in its distribution the horse is a strictly Old World form, that isolated fact tells us but little of the history of the race. Even if we discover that the fossil remains of horses occur in the Tertiary deposits of America as well as in those of Europe, the knowledge of that fact may certainly enlarge our ideas of the former distribution of horses, but of itself the fact does not place us in possession of any connected details concerning the general history of the form in question. But when, by bringing these varied facts into relation with each other, we seek to construct a pedigree of the equine race, we then illustrate the higher use of our knowledge, in that we cause that knowledge to explain itself.

Of all the facts of distribution, the same opinion may be expressed. Formerly, to say that a given animal was found in this land or that, was accounted the beginning and end of distributional science. The influence of evolution, and the growth of newer ideas concerning the modification of species, have together created for us a literally new science of distribution. The ideas which prevailed a quarter of a century ago regarding the fixity of species, and the consequent fixation within certain limits of their habitats, demanded no further exercise of scientific acumen than that necessary to say from what region any given organism was derived, or from what tracts it was absent. With altered ideas of the constitution of the animal and plant worlds, higher and better because truer conceptions of the manner and causes of the distribution of life on the globe grew apace. In the days of Edward Forbes, the doctrine of "specific centres" held its own as representing the foremost science of its day and generation. With the dogma of the special and independent creation of each species of living beings left utterly

unquestioned, it was of all logical processes the most natural that a "special centre" of creation should be sought and found for each species. This theoretical "specific centre" was allocated, *cæteris paribus*, in the region where the species was found to be most abundantly represented. The diffusion of a species beyond its centre was due, it was held, to such favouring influences as continuous land surfaces, the presence of food in surrounding regions, favourable temperatures and climates, and like conditions. The limitation of a species to its centre or original area was held, conversely, to depend upon an absence of the conditions favouring migration and dispersion. The presence of rivers, lakes, or seas, the existence of land-barriers in the shape of mountain chains, extremes of temperature and vicissitudes of climate and other causes, were regarded as the means whereby a species was confined more or less strictly within its area.

But the growth of the idea that the existing species of animals and plants were the descendants, by ordinary generation, of pre-existing species, wrought a wonderful and sweeping change in biological opinions concerning distribution, as in every other department of natural-history science. The theory of the separate and detached placing of animals and plants here and there over the surface of the earth, in obedience to no ascertainable law, was soon driven to the wall as a weak invention possessing no logical standpoint whatever. Affording no reason for the marvellous diversities of life's distribution, the doctrine of "specific centres" was soon consigned to the limbo reserved for the myths and traditions of biology. To say that providential reasons—namely, the necessity of a fatty dietary on the part of the Esquimaux—accounted for the presence of seals and whales in the Arctic regions, or similarly, that farinaceous plants grew most plentifully in the tropics because the inhabitants thereof fed upon their products, might indeed satisfy primitive minds, preferring to bring scientific facts under the sway of dogma rather than to test dogma by the logic of facts. Moreover, all such apologetic attempts at correlating the facts of distribution with theoretical interpretations of the designs of Providence missed their mark, because in placing man in the first place, and the distribution of life in the second, they reversed not merely the chronological order of affairs, but subverted the real aspect of the case. Thus, clearly, no explanation of the "whys" of distribution was forthcoming from former aspects of this study, just as the "hows" of the science were equally neglected. The newer era of research inaugurated by the publication and growth of Mr. Darwin's opinions, derived no small share of its power and progress from its ability to explain the "how" and "why," not merely of distribution, but of other departments of biology. Evolution, for example, gave a reasonable explanation of the *metamorphosis*

or series of changes through which many animals pass, externally to the egg, in their development. The tadpole, as every schoolboy knows, grows to be a frog through successive changes converting it from a fish-like organism into the type of the air-breathing terrestrial adult. The caterpillar, through equally well-marked alterations of form, becomes the butterfly or moth. Under the old idea of zoological causation, either form undergoes metamorphosis, because, to quote the words of Kirby and Spence, "it is the will of the Creator." "This, however," as Sir John Lubbock remarks, "is a confession of faith, not an explanation of metamorphosis." Evolution satisfactorily and finally replaces the want of rational ideas of metamorphosis by a higher idea of satisfactory causation, namely, heredity. The frog passes in its development through a metamorphosis, because its ancestor was a fish-like organism. It repeats, as an individual frog, the history of its race. So, also, an insect may directly or indirectly be credited with demonstrating, by the course of its development, its origin from lower stages of life. The development of every animal is a brief recapitulation of the descent of its species. Obscured, and often imperfect, that biography may be, but nevertheless it is plainly outlined before the seeking eye and understanding mind.

If evolution has thus assisted our comprehension of why an animal passes through apparently useless stages in the course of its development, no less clearly has that theory brought to light the meaning of the previously isolated facts of distribution. It was evolution which played to these facts the part of a guardian genius; marshalling their ranks into order and arrangement, and demonstrating that relationship between them which it is the province of science to explain. It is necessary to dwell upon the influence which evolution has exerted upon the study of distribution, simply because the latter science practically dates its origin from the day when the modification of existing species as a means of natural creation of new races of animals and plants was recognised. And it is with the greater satisfaction that one may dwell upon this mutual relationship of distribution and the theory of development, since the due appreciation of the clear explanation which the facts of distribution receive from evolution at large, constitutes a powerful counterproof of the truth of that theory. It is not surprising, therefore, to find Professor Huxley saying that "no truths brought to light by biological investigation were better calculated to inspire distrust of the dogmas intruded upon science in the name of theology, than those which relate to the distribution of animals and plants on the surface of the earth. Very skilful accommodation was needed," continues Huxley, "if the limitation of sloths to South America, and of the ornithorhynchus to Australia, was to be reconciled with the literal

interpretation of the history of the Deluge; and with the establishment of the existence of distinct provinces of distribution, any serious belief in the peopling of the world by migration from Mount Ararat came to an end. Under these circumstances, only one alternative was left for those who denied the occurrence of evolution—namely, the supposition that the characteristic animals and plants of each great province were created as such within the limits in which we find them. And as the hypothesis of 'specific centres' thus formulated was heterodox from the theological point of view, and unintelligible from the scientific aspect, it may be passed over without further notice as a phase of transition from the creational to the evolutional hypothesis. In fact," adds Huxley, "the strongest and most conclusive arguments in favour of evolution are those which are based upon the facts of geographical, taken in conjunction with those of geological, distribution."

Or if we turn for a moment to the opinion of Mr. Darwin himself, we shall find an equally clear expression of the futility of the attempt to explain distribution on any other save an evolutionary understanding. In his classical work, the "Origin of Species," Darwin remarks the fact that "neither the similarity nor the dissimilarity of the inhabitants of various regions can be wholly accounted for by climatal and other physical conditions." He secondly notes the fact, "that barriers of any kind, or obstacles to free migration, are related in a close and important manner to the differences between the productions of various regions;" and a third fact noted by Darwin is "the affinity of the productions of the same continent or of the same sea, though the species themselves are distinct at different points and stations." Again, Darwin remarks that, "in discussing this subject we shall be enabled at the same time to consider a point equally important for us, namely, whether the several species of a genus, which must on our theory all be descended from a common progenitor, can have migrated, undergoing modification during their migration, from some one area. If, when most of the species inhabiting one region are different from those of another region, though closely allied to them, it can be shown that migration from the one region to the other has probably occurred at some former period, our general view will be much strengthened, for the explanation," adds Darwin, "is obvious on the principle of descent with modification. A volcanic island, for instance, upheaved and formed at the distance of a few hundreds of miles from a continent, would probably receive from it in the course of time a few colonists, and their descendants, though modified, would still be related by inheritance to the inhabitants of that continent. Cases of this kind are common, and are, as we shall hereafter see, inexplicable on the theory of independent creation."

If further evidence were desirable concerning the influence of evolution as explanatory of the distribution of living beings in the past and present of the earth, such opinion might be culled from Sir Charles Lyell. The late eminent geologist remarks, that Buffon, when speculating on "philosophical possibilities," in 1755, urged, "that whilst the same temperature might have been expected, all other circumstances being equal, to produce the same beings in different parts of the globe, both in the animal and vegetable kingdoms, yet it is an undoubted fact, that when America was discovered, its indigenous quadrupeds were all dissimilar to those previously known in the Old World." "Thus Buffon," says Lyell, "caught sight at once of a general law in the geographical distribution of organic beings, namely, the limitation of groups of distinct species to regions separated from the rest of the globe by certain natural barriers." In conformity with the doctrine of special centres of creation, as Lyell remarks, the "natural barriers" of Buffon held a perfectly logical place. Separate creations in the New World, and special creations in the Old, separated by intervening oceans, served fully to explain the reasons of the divergence between the animal populations in question. "But," adds Lyell (in further alluding to the close correspondence between the fossil forms and the living beings of any given area), "the intimate connection between the geographical distribution of the fossil and recent forms of mammalia, points to the theory (without absolutely demonstrating its truth), that the existing species of animals and plants . . . . are of derivative origin, and not primordial or independent creations."

Last of all, Mr. Alfred Russel Wallace—to whose labours we owe much, if not the greater part, of the light which has been thrown on the formerly obscure problems of distribution—testifies in the most direct terms to the value of the theory of evolution. Towards the firm establishment of this theory he himself has made many important contributions, and has thus aided its place and power in explaining the laws regulating the development of life on the surface of the globe. "We further have to make use of the theory of 'descent with modification,'" says Mr. Wallace, "as the only possible key to the interpretation of the facts of distribution; and this theory," he adds, "has only been generally accepted within the last twenty years. It is evident that so long as the belief in 'special creations' of each species prevailed, no explanation of the complex facts of distribution *could* be arrived at, or even conceived; for, if each species was created where it is now found, no further inquiry can take us beyond that fact, and there is an end of the whole matter." Again, we find a sentence worth quoting, and worth bearing in mind, when Mr. Wallace remarks, that "if we keep in view these facts—that the minor features of the earth's surface are everywhere slowly changing; that the forms, and structure, and

habits of all living things are also slowly changing; while the great features of the earth, the continents, and oceans, and loftiest mountain ranges, only change after very long intervals, and with extreme slowness; we must see that the present distribution of animals upon the several parts of the earth's surface is the final product of all these wonderful revolutions in organic and inorganic nature."

The proposition that in the existing world we may find a reflex of those causes which have wrought out the scheme of life's distribution over the surface of the globe, has received the tacit sanction and approval of all competent biologists. This result has been attained through the slow but sure and progressive advance of modern ideas concerning the uniformity of natural law and physical causation. The teachings of evolution in biology are but the reflections of "uniformity" in geology. As the doctrine of uniformity has taught us that the physical forces represented in and by the internal heat, water, frost, snow, and chemical action are the agencies which from all time past have been sculpturing and moulding our earth's features —as we trace in the physical actions of the present the key to the activities of the past—so in biology we assume, and assume logically, that the ordinary activities of life, the processes of variation and change and the influence of environments on the living form, are the agencies which mould the world of life now, as in the earliest æons, and as in the beginning itself. Rejecting the idea of uniformity in science, we fall back on the catastrophism of primitive geology and on the "special creation" of those early times of biology, when fabulous theory represented the exact observation of to-day. Accepting, however, the theories of "uniformity" in the inorganic world and of "evolution" in the living universe, we unite the sciences in a circle, outside the magnificent unity of which no fact of inorganic nature or of the living world can be presumed to exist.

The division of the world's surface for the purposes of ordinary geography is obviously unsuited to the wants of the biologist. The geographical survey of the earth is of necessity a matter of politics. The greater nation tends to obliterate the smaller; allocation of territory is largely a matter of division of spoil; and the outlines and boundaries of the countries of the world reflect the kaleidoscopic change which marks the arena of political strife and its concomitant warfare for its own. For scientific purposes, then, the standpoints of the political geographer are unavailable. Save in so far as the march of civilisation means and implies the destruction and repression of the animals and plants which are either useful or useless and dangerous to man, the distribution of life on the globe is comparatively unaffected by the divisions whereby man demarcates his territorial possessions from those of his neighbours. A rat may pass

as placid an existence under the Czar as under British rule: a kangaroo will live as successfully beneath Dutch as under English sovereignty; but there may be more prospect of length of days for the hippopotamus under existing circumstances than under an extension of civilisation in the north of Africa. Neglecting, then, the political divisions of the world, the biologist divides the earth's surface into regions, the boundaries of which are determined solely by the distribution of the animals and plants included within their limits. Sweeping aside the lines of demarcation which human powers and aims have constructed, the naturalist constructs a new biological geography, whose continents and countries are under the unceasing sway and sovereignty of those natural forces, agencies, and laws which from all time past have affected the destinies of the earth and its tenants. It is on the very threshold of distribution that we begin to note the wide variations between the former and present methods of studying life's development over the globe's surface. Formerly, the range of any living being was denoted simply by the name of the country or continent in which it occurred.

But it is evident that such a method of indicating an animal's territory is in the highest degree indefinite. To speak, for instance, of India as the habitat of the tiger, is to imperfectly indicate the range of that animal, which extends over at least two-thirds of the continent, besides being found in the Eastern Archipelago. Or, if we select one or two common British quadrupeds, we may find the anomalies of the common method of naming the habitats of animals to be equally well represented. For instance, the badger is commonly described as being found in Europe. Such a method of denoting its range tends to imply that its distribution is limited to that continent. But in point of fact, the badger ranges eastwards from Central Asia to Amoor, and southwards to North Africa as well. The otter's distribution ranges to North Africa, and extends to Siberia; the hedgehog is found from Central Asia to Amoor, like the badger; and the mole extends as far as Central Asia. Certain of our birds fall equally without the common indications of distribution. Our grey wagtail (*Motacilla sulphurea*) extends to North Africa, and occurs also in Central Asia, China, and Malaya; and the house-sparrow, fieldfare, starling, and crow, have a distribution varying from Britain to North Africa and Central Asia. The inadequacy of ordinary descriptive geography to indicate the range of these animals can therefore be readily understood. In the nature of things, the distribution of animals and plants follows certain laws which have left their impress upon the boundaries of land-regions likewise. It remains for us to see how the earth's surface has been mapped out by these laws into natural continents or regions, each characterised by its own characteristic fauna and flora. The popular

description of animal and plant distribution, moreover, besides affording no exact details of the boundaries of its regions, gives no information concerning the causes which limit an animal to a small area in one case, or which extend an animal's range over a wide area in another. On the contrary, when, taking as our guide the natural divisions of earth's population, we discover the exact distribution of animals and plants, we lay thereby the foundation of the knowledge which shows how that distribution has been attained and regulated.

FIG. 12.—OPOSSUM.

It is not sufficient, for instance, for any intellectual purpose, to know why kangaroos are found in Australia alone. The mind naturally proceeds further, and inquires, why should these animals be limited to the region in question? It by no means conveys any adequate information concerning the distribution of the marsupial or "pouched" order of quadrupeds to be told that all known members of the group, kangaroos included, are confined to the Australian region, with the single exception of the true opossums or *Didelphidæ*—these latter animals occurring in the New World, but being absent from Australia. The natural queries, why should kangaroos be confined to Australia, and why should the opossums (fig. 12) alone of all marsupials be found without the bounds of Australia, are not answered by the mere geographical descriptions of former days. Nor do these descriptions indicate why, to select other examples, Australia is practically destitute of all higher quadrupeds; or why antelopes have their headquarters in Africa, where, south of the great desert, deer do not typically occur, whilst deer are found in all other regions save Australia. So also the mere note of an animal's country as politically defined, and the mention of the fact that bears inhabit Europe, Asia, and North America, gives no explanation why these animals are absent from tropical and South Africa.

The pigs, again, are common over Europe and Asia down to New Guinea, yet Southern Africa knows not this race any more than it includes the deer amongst its denizens. Nor can we explain according to ordinary geographical notions, why tapirs should exist in regions so far apart as Malaya and South Africa, or why camels and llamas should inhabit the Asian deserts and the slopes of the Andes respectively. Or, last of all, how impossible of explanation, on ordinary grounds, is the fact that the anthropoid or man-like apes occur in regions so widely separated as Western Africa and Borneo.

It is clear, therefore, that our glance at the world's geography in relation to the distribution of life must go deeper into the nature of things than do the common descriptions of the countries tenanted by animal and plant races. Here, as in other departments of scientific inquiry, we require to refer to a former state of things, and to glance backwards in time for the true solution of the problems of life's development over the globe. The naturalist of to-day thoroughly endorses Mr. Wallace's statement, that "to the older school of naturalists the native country of an animal was of little importance except in so far as climates differed. . . . . A group of animals was said to inhabit the 'Indies'; and important differences of structure were often overlooked from the idea that creatures equally adapted to live in hot countries, and with certain general resemblances, would naturally be related to each other. . . . . To the modern naturalist, on the other hand, the native country (or 'habitat,' as it is technically termed) of an animal or a group of animals is a matter of the first importance; and as regards the general history of life upon the globe, may be considered to be one of its essential characters."

That certain divisions, or "regions," bounded by distinct lines of demarcation, exist to represent the natural method of distribution of animals or plants on the earth's surface, is a fact readily provable. For example, one of the most remarkable results attained through the investigation of the distribution of animals and plants, is the fact that a line passing between the little islands of Bali and Lombok in the eastern archipelago, and separating Borneo, Java, and the Philippines from Celebes, New Guinea, and Australia (see fig. 13), serves as a boundary between two regions exhibiting the greatest diversity in their animal and plant life. On the Borneo side of this line we have a rich collection of higher quadruped life—man-like apes, lemurs, monkeys, antelopes, tigers, rhinoceroses, and other forms—along with the babblers, hill-tits, bulbuls, crows, hornbills, pheasants, and jungle-fowl among the birds. On the Australian side, not a single higher quadruped (if we except a few bats, and rodents of recent introduction) is native; and the kangaroos and their neighbours represent the fulness of quadruped life in the archipelago. The special birds of the archipelago have for the most part disappeared. The bulbuls, pheasants, barbets, and vultures, find no place in the Australian islands; but in their place we find the curious honeysuckers, the piping crows, the lyre-birds, the cockatoos, lories, and parroquets, the brush-turkey and mound birds, emus and cassowaries, and other characteristic forms. It is difficult to imagine a change of fauna so complete as that which meets the eye of the traveller as he passes across the narrow straits of Lombok to enter the Australian region. Yet the divergence is of the most characteristic nature, and depends upon the causes which lie at the

root not merely of physical but of biological change. The remark-

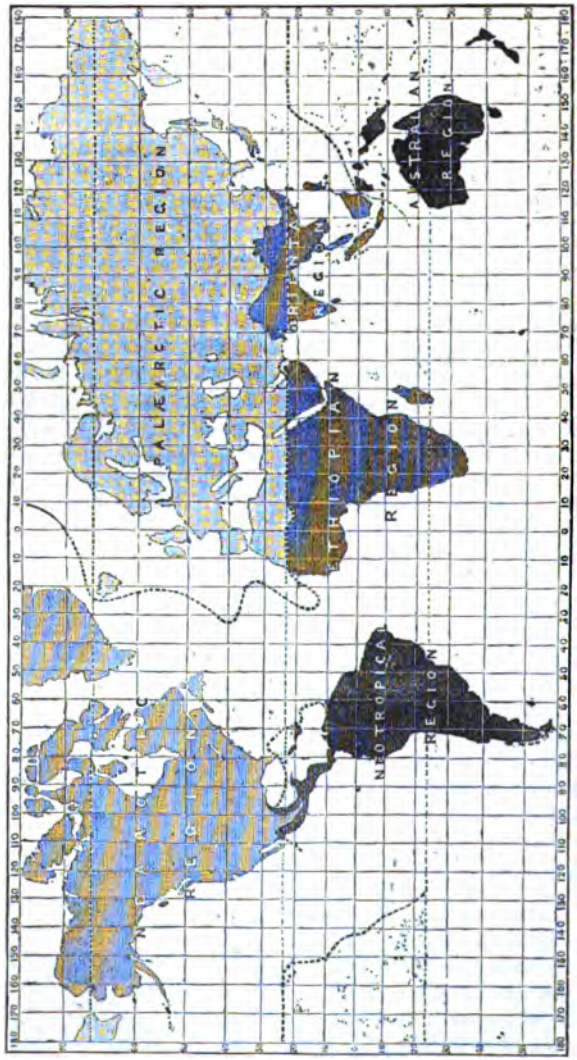

FIG. 13.—MAP OF THE ZOOLOGICAL PROVINCES.

able fact that the animals common to Europe and Central Asia pass into Africa north of the desert, but are not, as a rule, found in India,

is similarly explicable on the ground that the distribution of life shows us the natural divisions and natural geography of the globe. It now remains to investigate the limits and boundaries of these divisions (or "zoological regions," as they are named), to indicate the more familiar types of life resident in each, and to ascertain, last of all, the chief facts which, when brought into scientific relationship, serve to explain how and why the life of the earth has been thus distributed.

Mr. Sclater, the secretary of the Zoological Society of London, proposed, from a consideration of the bird-life of the globe, to divide the earth's surface into six provinces or regions. These regions, whilst indicating the distribution of the birds, likewise serve to show that of the quadrupeds; whilst it is found that they also represent the essential features of the distribution of still lower grades of life. Mr. Sclater's six divisions have received, with one or two modifications, the common approval of naturalists. Professor Huxley, it is true, has proposed a somewhat different division of the earth's surface, and it may be convenient in the first place to note this latter arrangement. Making four provinces from the consideration of the distribution of fauna, Huxley divides the earth's surface as follows:—

Zoological Province	Geographical Equivalents
I. Ornithogæa or Nova-Zelanian	New Zealand alone.
II. Antarctogæa or Australian	Australia, Tasmania, and Negrito Islands.
III. Dendrogæa or Austro-Columbian	South America, Central America, and Mexico.
IV. Arctogæa. Having as sub-provinces	(1) North America (N. of Mexico). (2) Africa (S. of Sahara). (3) Hindostan. (4) Europe, Asia (except India), and Africa (N. of Desert).

The effect of this arrangement is to bring prominently into view the biological peculiarities of New Zealand, Australia, and South America, and to relate more nearly together those quarters of the globe (Europe, Asia, India, and Africa) which possess more features in common than the other and more specialised provinces. With all deference to such high authority as Professor Huxley in himself represents, one objection to his system of zoological geography may be found in the fact that the claims of New Zealand to rank as a distinct zoological region are highly debatable. Again, in the system propounded by Mr. Sclater, the geographical equivalents of Huxley's *Arctogæa* are practically retained, and the not inconsiderable merit of simplicity, as well as considerations relating to the distinctness of the fauna, may weigh in the minds of naturalists as favouring the adoption of Mr. Sclater's provinces of distribution.

These provinces or regions, depicted in fig. 13, are as follows:—

I. Palæarctic Region . .	includes Europe, Africa N. of the Desert, and Asia (except India and the Eastern Peninsula).
II. Oriental (or Indian) Region	includes India and the Eastern Peninsula and Archipelago to "Wallace's Line."
III. Australian Region . .	Australia, New Guinea, New Zealand, and Eastern Archipelago S. of "Wallace's Line."
IV. Ethiopian Region . .	Africa S. of the Desert, and Madagascar.
V. Nearctic Region . .	North America, down to Central America.
VI. Neotropical Region . .	South America, West Indian Islands, and Southern Mexico.

Beginning with the *Palæarctic Region* (fig. 13), or the first of the six great provinces into which the biologist maps out the earth's surface, we may, in each case, firstly define the geographical boundaries of the province; next note the leading groups of living beings which characterise the region; and finally discuss its sub-regions wherever these latter present any features of striking interest. The constitution and limits of the Palæarctic Region introduce us at once to the revolution in geographical ideas which the study of distribution entails. We shall find therein a typical instance of that apparently arbitrary division of continents and piecing together of diverse lands, beneath which lies, in reality, the true relationship of the land areas of our globe. The Palæarctic Region of the biologist consists (1) of Europe in its entirety; (2) Asia, except India and the Eastern Peninsula, along with as much of Africa as lies north of the Desert. In the "mind's eye" we must, therefore, separate out the areas just mentioned from those with which, in ordinary geography, they are so intimately associated, and, piecing them together, form a great zoological province. This province is characterised, as are the other five divisions, by the possession of animals and plants which, for the most part, remain characteristic of its limits. Here and there we may detect a commingling with the forms of adjoining regions, and occasionally we may meet with a group which is common to two or more regions. Sometimes we see groups—such as the crows, swallows, owls, and pigeons among birds, or the rats and mice among quadrupeds—which have representatives in every region, and are thus cosmopolitan, or nearly so, in their distribution. But, apart from these exceptional instances, the main zoological and botanical features of each region are readily distinguishable; and no less so, as a rule, are the sub-regions into which each province is divided from considerations connected with the prevalence of special groups of animals in certain localities.

The quadrupeds of the Palæarctic Region include many familiar forms. As compared with the region most closely resembling it—

namely, the Nearctic—this first region possesses a much greater variety of quadrupeds and birds. A very fair representation of all the higher animals is found in the Palæarctic province. With the exception of the monkey of Gibraltar—an importation from Northern Africa—and the Japanese ape, no apes occur in this region. The bats are not markedly peculiar, but the whole of the mole family, save one American and two Oriental species, is included within its limits. Of carnivora it has a fair share, although the larger beasts of prey are well-nigh absent. There are numerous lynxes; wolves, foxes, and bears are plentiful but not peculiar; the badgers occur typically here, whilst Japan has a peculiar dog (*Nyctereutes*) and a special otter (*Lutronectes*). The Ungulates, or hoofed animals, include the camels, which are typical tenants of the Palæarctic Region; there are six genera of deer peculiar to the region, along with seven peculiar genera of the ox family (chiefly antelopes), such as the chamois and saiga. This region may be described as the head-quarters of the sheep and goats, since but two species (one American and one Indian) exist without its bounds. The *Rodentia*, or "gnawers," are well represented likewise. Twenty-seven rodents occur nowhere else, and those genera occurring in other regions—such as the voles, pikas, and dormice—still possess representatives in the Palæarctic territory. The birds of this region, like the quadrupeds, present us with many well-known genera and species. The true pheasants are wholly limited to this region, if we except one species found in Formosa; the corncrake, the great bustard, and the sand-grouse, are specially Palæarctic. Of smaller birds this region has likewise its typical representatives. The grasshopper-warblers (*Locustella*), the true warblers (including the robins), the bearded titmouse, the wrynecks, the magpies, choughs, and nutcrackers are characteristic of this region. The reptiles and amphibians are relatively few. There are, however, at least two genera of snakes, seven genera of lizards, eight frogs and toads, and eight newts and salamanders which the region claims as its own. The fresh-water fishes peculiar to this territory, it may be added, number about twenty genera. The sub-regions number four. Of these, Central and Northern Europe, with their peculiar Desman-rat and chamois, form one. The Mediterranean borders constitute another, and contain as peculiar animals the fallow-deer, the elephant shrews, the hyæna, the porcupine, and the coney. The Siberian sub-region forms a third, and is the special home of the yak, or hairy bison of Thibet, the Thibetan antelopes, and a peculiar mole; whilst in the fourth sub-region, formed by Japan and Northern China, we find special forms of monkeys, moles, and other quadrupeds, the most notable being a carnivorous animal, the *Æluropus*.

Turning next to the *Ethiopian* region, we discover this latter

province to include Africa south of the Desert, whilst the island of Madagascar forms a notable sub-region. In Ethiopia there are many characteristic quadrupeds and peculiar birds which do not occur outside the limits of the region. On the west coast occur two of the four genera of anthropoid apes—the gorilla and chimpanzee. Here also are found the baboons; and the lemurs, having their headquarters in Madagascar, also occur on the mainland. The lion possesses the continent as ruler of the carnivora; the spotted hyæna is found here alone; the hyæna-dog and aard wolf are likewise typically Ethiopian. No less special to this territory are the zebras, giraffe, hippopotamus; whilst the region has likewise its own species of rhinoceroses. More than seventy species of antelopes (fig. 15) attest the fact that the race finds its home in this territory; and the African elephant is a peculiar genus and species. But the deficiencies in the quadruped - population of Ethiopia are likewise interesting; and we thus detect the absence of the deer, bears, and oxen, so conspicuous in other regions. The birds of the region are numerous. Limited to Ethiopia are the plantain-eaters, ground hornbills, colies, secretary bird, whydah-finches, ox-peckers, guinea-fowls, and the ostriches; we look in vain for the wrens, creepers, nuthatches, pheasants, and jungle-fowl in the lists of Ethiopian fauna. The reptiles, amphibians, and fishes at present include three families of snakes, one family of lizards, one of toads, and three of fresh-water fishes, as absolutely peculiar to the region. The puff-adders and chameleons represent reptiles peculiar to the province under consideration. Whilst the Palæarctic region possesses 35 genera of mammals

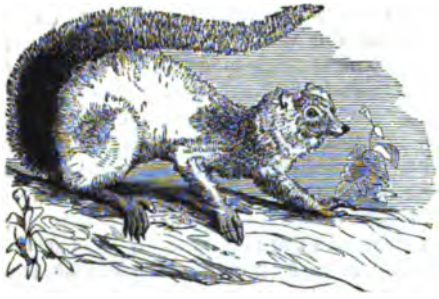

FIG. 14.—LEMUR.

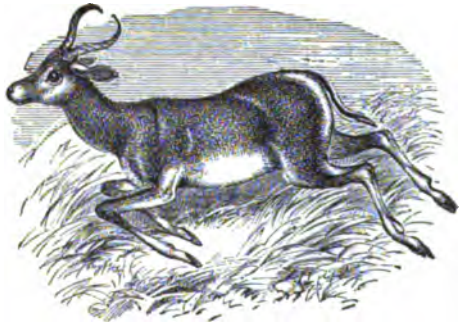

FIG. 15.—ANTELOPE.

peculiar to itself, as well as 57 genera of birds, the Ethiopian boasts of 90 peculiar quadruped genera, and 179 genera of land birds absolutely confined within its limits.

The Ethiopian sub-regions number four—being named the East, West, and South African, and Malagasay or Madagascar provinces, respectively. Of these the Madagascar sub-region alone demands a passing notice. Including, besides the great island from which it derives its name, the Mauritius, Bourbon, Rodriguez, and the Seychelles and Comoro Islands, the Madagascar sub-region becomes notable in zoological eyes from its forming the headquarters of the lemurs or lower apes, and of the Insectivora. In addition to these quadrupeds, Madagascar possesses a few special carnivora (*e.g. Cryptoprocta*) of small size; but in this island the apes, lions, leopards, antelopes, and other familiar quadrupeds of Africa are entirely wanting. In Madagascar there are represented 12 families, 27 genera, and 65 species of quadrupeds. Of these 3 families and 20 genera are exclusively found in the island, and all the species of these families and genera are similarly peculiar, except perhaps a few of the bats. Extremely peculiar it is to find the lemurs so typical (including 2 families and 34 species) of Madagascar; these animals being represented on the west coast by two forms, and in Africa by one group, whilst they flourish elsewhere in numbers only in the Eastern Archipelago and in Southern India. As regards its bird-population, Madagascar owns 111 species of land birds, of which only 12 are identical with species inhabiting the adjacent continents. Thirty-three genera of birds are peculiar to the island, these genera including fifty species. Of Madagascar Mr. Wallace remarks, in speaking of its quadruped fauna, "the assemblage of animals above-noted is remarkable, and seems to indicate a very ancient connection with the southern portion of Africa, before the apes, ungulates, and felines had entered it. The lemurs (fig. 14), which are here so largely developed, are represented by a single group in Africa, with two forms on the west coast. They also reappear under peculiar and isolated forms in Southern India and Malaya, and are evidently but the remains of a once widespread group, since in Eocene times they inhabited North America and Europe, and very probably the whole northern hemisphere." Again, remarking of the birds of Madagascar, Mr. Wallace says: "So many perfectly isolated and remarkable groups are certainly nowhere else to be found; and they fitly associate with the wonderful aye-aye (*Chiromys*), the insectivorous Centetidæ, and carnivorous *Cryptoprocta* among the mammalia. They speak to us plainly of enormous antiquity, of long-continued isolation; and not less plainly of a lost continent or continental island in which so many, and various, and highly-organised creatures could have been

gradually developed in a connected fauna of which we have here but the fragmentary remains."

The *Oriental* region, formerly known as the "Indian" region, possesses boundaries of highly interesting nature. Comprising Asia south of the Palæarctic region, it includes India, the Eastern Peninsula, and the Malay archipelago as far as Borneo, Java, and the Philippines. Its southern or lower boundary is marked by a special line—"Wallace's line"—which passes through a narrow but extremely deep channel—the Straits of Lombok—running between the little islands of Bali and Lombok (fig. 13), and, extending northward and eastward, leaves on its Australian side Lombok, Celebes, and adjoining islands. No fact of distribution, as has been already remarked, is more noteworthy than the sharp demarcation of the Oriental from the Australian region. In the Oriental province itself are found all the conditions for a rich development of life. There is variety in its physical contour; it is broken up into islands and peninsulas; it has its alternations of high mountain and valley, of hill and plain; its river-systems are many and extensive; its temperature is that of the equatorial zone, and its vegetation is in consequence varied and profuse.

Peculiar to the Indian region are at least three families of quadrupeds, that of the flying-lemurs, that of the Tarsiers, or spectre-lemurs, and that of the Tupaias, or squirrel-shrews. There are also many genera confined to this province, although possessing family representatives elsewhere. Thus there are monkeys of the genus *Presbyter*, and the special genera of true lemurs in this region; twelve peculiar civet cats find a home here; whilst three species of antelopes, five rhinoceroses, and the flying-squirrels (*Pteromys*) are typically Oriental in their distribution. Nor must we neglect the species which are limited to this province. The orang-outangs and gibbons, two of the four kinds of highest apes, are included amongst its denizens; the tiger, the Indian elephant, sun-bears and honey-bears, the tapir, and the chevrotains or mouse-deer, lend their presence to aid in forming a diverse fauna of the most interesting kind.

Conspicuous among its birds are the tailor-birds, which are peculiar to the region, as also are the laughing-thrushes. There are peculiar genera of woodpeckers, cuckoos, and hornbills. The minivets and grass-green fruit-thrushes are also characteristic Oriental birds. The sun-birds are represented by three genera; bee-eaters and kingfishers are likewise included in the Oriental aviary; and goatsuckers and whiskered swifts also fall to be enumerated. Only two parrot-genera are Oriental in distribution; the pigeons of the province being the fruit-eating *Treron* and *Carpophaga*. It is in this region that the races of "poultry" find their original home. The true jungle-fowl, from one species of which all our domestic fowls

have sprung, occurs widespread in this region. The peacocks, argus pheasants, and fire-backed pheasants, are also typical denizens of the Oriental province, and may fitly close the list of its bird inhabitants.

The reptiles of the Indian region are numerous, but there are only some three small families of snakes which are peculiar and limited to the region. The reptile population, apart from its specifically distinct character, is varied enough, however. It includes a whole host of snakes; amongst lizards it numbers the water-lizards (or *Varanidæ*), the skinks, the geckos, and the iguanas (*Iguanidæ*). The crocodiles are numerous, and fresh-water tortoises, amongst other genera, abound. The tree frogs and true-frogs are well represented, and in its fresh-water fishes this region is peculiar. The Oriental province, to sum up, possesses at least twelve families of vertebrates peculiar to itself. Of the 118 genera of quadrupeds, 54 are confined to this province; and whilst 342 genera of land birds inhabit the region, 165 are absolutely confined to it. There are some four sub-regions included in the Oriental region. These do not demand special mention here, but it may be remarked that the Malayan sub-region—including the Eastern Peninsula, Borneo, Sumatra, Java, and the Philippines—is to be accounted the most typical area of the Oriental region. It is in the Malayan sub-region that we see the features of the Oriental province in their most typical development in most varied array.

Selecting as our fourth region the *Australian* province, the striking characters of this region have already been commented upon. Crossing "Wallace's line," we enter upon a biological territory marked by more peculiar features and by more divergent lines than those which separate the flora and fauna of any other two regions from one another. In Australia and New Guinea—as was to be expected from the fact of these islands presenting the chief areas of the region—the specialised character of its animals and plants is best seen. In Celebes this character is still preserved, although the denizens of that island do not present the special features of Australia, whilst the influence of Oriental migrations is clearly traceable. Of the life of New Zealand, which along with Polynesia falls within the Australian region, a more pronounced opinion may be expressed. The animals and plants of the New Zealand islands are in many respects so peculiar that, as we have seen, it has been proposed to include these areas in a special region. But, as we shall hereafter note, there exist other considerations, which, whilst explanatory of the divergence of New Zealand from the Australian types, nevertheless show its fundamental alliance therewith. Thus New Zealand comes, logically enough, to form a part of the Australian region.

Primarily, then, in the Australian region we find at once

striking likenesses to, and differences from, the New Zealand flora. Sir Joseph Hooker, speaking of the relations between the plant-life of the two regions, says: "Under whatever aspect I regard the flora of Australia and of New Zealand, I find all attempts to theorise on the possible causes of their community of feature frustrated by anomalies in distribution, such as I believe no two other similarly situated countries in the globe present. Everywhere else I recognise a parallelism or harmony in the main common features of contiguous floras, which conveys the impression of their generic affinity at least being affected by migration from centres of dispersion in one of them, or in some adjacent country. In this case it is widely different. Regarding the question from the Australian point of view, it is impossible, in the present state of science, to reconcile the fact of *Acacia*, *Eucalyptus*, *Casuarina*, *Callitris*, &c., being absent in New Zealand, with any theory of trans-oceanic migration that may be adopted to explain the presence of other Australian plants in New Zealand; and it is very difficult to conceive of a time or of conditions that could explain these anomalies, except by going back to epochs when the prevalent botanical as well as geographical features of each were widely different from what they are now. On the other hand, if I regard the question from the New Zealand point of view, I find such broad features of resemblance, and so many connecting links that afford irresistible evidence of a close botanical connection, that I cannot abandon the conviction that these great differences will present the least difficulties to whatever theory may explain the whole case." Thus, whilst there are clear botanical affinities between Australia and New Zealand, these likenesses are really limited to plants which form the characteristic part of the New Zealand flora; and these plants, for the most part, belong to temperate species.

FIG. 16.—APTERYX.

If the relations between New Zealand and Australia in the matter of their respective floras are so intricate, the relations between the animal populations of these areas are equally interesting. We may briefly glance, in the first place, at the New Zealand fauna, and then, by way of contrast, concern ourselves more especially with the animal life of Australia. The New Zealand islands, in superficial area, attain a size nearly equal to that of Italy. Their distance from Australia is about 1,200 miles; their vegetation is abundant and well distributed, owing to the absence of desert-lands.

The zoology of New Zealand is peculiar. It has no native quadrupeds, if we except a couple of bats; it possesses an almost Hibernian freedom from reptiles in that it has no snakes, only three genera of lizards, and but one frog. There are 34 genera of land birds, and of these 16 are absolutely confined to New Zealand; and to these are to be added five special genera of aquatic birds, making 21 marked genera in all. Amongst their birds, these islands include the chief species of "wingless" forms. The Moas of New Zealand represent an extinct wingless race, whilst the curious *Apteryx* (fig. 16) remains to represent the wingless tribes of to-day. The winged birds include special forms of starlings (*Creadion: Heterolocha*, &c.); the curious crook-billed plovers (*Anarhynchus*), which alone of all birds have the bill twisted to the side; and species of swallows, fly-catchers, &c., are also included in the ornithological catalogue of these islands. In New Zealand is found the kakapoe (*Stringops habroptilus*) or owl-parrot, which burrows in the ground, and whose powers of flight have deteriorated; and the curious *Notornis*, a peculiar genus of rails, likewise possessing short and useless wings, may be lastly mentioned amongst the bird productions of these islands.

Included amongst the few lizards of New Zealand is the famous *Hatteria*, which in reality forms a connecting link between lizards and crocodiles, and even shows bird-affinities in its ribs. Hatteria thus remains isolated and solitary in its structure amid the lizard-class.

FIG. 17.—KANGAROO.

Turning now to Australia itself, we note that land to be the abode of the lower quadrupeds comprised within the two orders *Monotremata* and *Marsupialia*, which are represented by the *Ornithorhynchus* and *Echidna*, and by the kangaroos (fig. 17), wombats, phalangers, and allied animals respectively. No monotreme whatever, and no marsupial forms—save the single family of the New World opossums—exist without the boundaries of Australia. These animals represent in their varied types the orders of higher mammals distributed over the other regions of the earth; and the Australian region thus presents us with the home and headquarters of the lowest, and, in

point of time or geological sequence, the earliest, quadrupeds. Whatever higher quadrupeds—such as the sheep, oxen, horses, &c.—the colonisation of Australia has been the means of introducing into that region, it must be borne in mind that all the native mammals of Australia are of the lower grades, and are, with the exception of the American opossums (which do not occur in Australia), absolutely limited to that region. Even the world-wide rodents, represented here by a few rats and mice, are probably of relatively late introduction.

In respect of its birds, whilst Australia possesses species of the familiar thrushes, warblers, shrikes, crows, &c., of the other regions, it yet exhibits certain peculiar forms of bird-life. The bird-absentees are of themselves typical, for Australia has no representatives of the vultures, pheasants, woodpeckers, barbets, and other birds which are so characteristic of even the Oriental territory. But it has, nevertheless, a rich ornithology of its own, in its birds of paradise, its most typical honeysuckers, its lyre-birds, its scrub-birds, its parroquets, its cockatoos, its mound-birds, and its cassowaries. These are typically Australian forms; and there are bird-families sparingly found in other parts of the world—such as the swallow-shrikes and flower-peckers—but which are well represented in Australia. Lastly, there are families of birds—such as the kingfishers, pigeons, weaver-finches—well represented in other provinces, and which are, as a rule, better represented in Australia than in other provinces.

The reptiles of Australia do not present any special features for remark. Snakes and lizards are plentiful; and the Australian amphibians number frogs and toads, but no newts, in their ranks. Thus the Australian region, to sum up, possesses representatives of eighteen families of quadrupeds, eight of these families being absolutely confined to this region. It has seventy-one families of birds, sixteen being peculiar; it possesses four peculiar families out of thirty-one of reptiles; and it has only one family of amphibians, out of a total of eleven, confined within its limits.

Passing now to the Western Hemisphere, we find the New World divided into the *Nearctic* and *Neotropical* regions (fig. 13). The former includes North America in its arctic and temperate regions, and is bounded on the south by a line running between Cape Lucas on the west, and the Rio Grande del Norte on the east; the boundary line dipping southwards from this point in a tongue which extends well-nigh to the Isthmus of Tehuantepec. Between the life of the Nearctic and Palæarctic regions there is a striking resemblance. In North American forests, the wolves, lynxes, foxes, bears, elks, deer, beavers, hares, squirrels, pikas, and marmots of Europe are represented often by similar species; and the bison of Western Europe represents the buffalo of the Nearctic prairies. But North America has its own peculiar quadrupeds likewise. For instance,

the skunk and other two genera of weasels are found nowhere but in Nearctic lands. Then there are the carnivorous racoons, which are likewise special forms; and among the rodents, the pouched rats (*Saccomyidæ*), the jumping mouse, the tree porcupines, and prairie dogs are peculiar. The Insectivora number three peculiar genera of moles. The pronghorn antelope (fig. 18) and the mountain goat are absolutely Nearctic. The opossums complete the list of peculiar mammals of the region; whilst the absentees may be summarised in the remark that the Nearctic region is chiefly notable for its absence of wild horses and pigs, dormice, oxen, and hedgehogs, and true mice and rats (*Mus*). The single native sheep, as against the twenty species of sheep and goats of the Palæarctic region, also typifies a remarkable deficiency of a widely distributed quadruped family.

The small birds of the Nearctic region are, as a rule, well marked off from those of the Palæarctic province. The North American warblers belong to different families from the Palæarctic forms; the Nearctic flycatchers belong likewise to different groups from those at home; and the starlings are really "hangnests," or *Icteridæ*. The birds peculiar to the Nearctic region are in turn well defined. The mocking-birds and blue-jays, the special cuckoos and the tanagers; the humming-birds; the wild turkeys and turkey buzzards, are all limited to this province. The humming-birds of the New World present certain extraordinary limitations in their distribution within the limits of the two regions comprising the Western Hemisphere. The peaks and valleys of the Andes possess each its own species. On Pinchincha a peculiar species occurs, 14,000 feet above the sea level, and nowhere else; another has been found only inside the crater of the extinct volcano of Chiriqui in Veragua; a third occurs only on Chimborazo; and of another species only one specimen has ever been seen, the bird in question having been obtained, over forty years ago, in the Andes of Northern Peru. Again, the presence of such distinct reptiles as the rattlesnakes among serpents, and the true iguanas among lizards, is highly characteristic of Nearctic lands. This region, lastly, may be described as the home of the tailed amphibians or newt-tribe.

FIG. 18.—PRONGHORN ANTELOPE.

Nine families—two peculiar to the region—and fifteen special genera represent the newts and salamanders, which include in their ranks the sirens, amphiumas, and two forms related to the European proteus of the caves of Carniola and the giant salamander of Japan respectively. There are also five families of fresh-water fishes—including two families of the rare ganoids—to be enumerated amongst the specific animal belongings of this large area.

There can be no question of the clear distinctness of the Nearctic region from all other regions, including the Palæarctic, to which, however, in the general characters of its animal life, it is so closely allied. The species that are really common are northern or Arctic forms, a fact which to some extent would seem to point to former land connections in the north as a cause of the similarity. Notwithstanding the likeness in question, the Palæarctic and Nearctic regions are essentially distinct; and there are no reasonable grounds for any scheme of uniting their varied interests in one common biological territory.

FIG. 19.—SPIDER MONKEY.

The Neotropical region extends from the southern limits of the Nearctic region, and includes the remainder of the New World—that is, Central and South America—with the West Indian Islands as a subregion of the territory. No region of the world, if we except the Australian province, presents such a variety of interesting biological features as the Neotropical province. Whether regarded in the light of its existing life and of the diversity of animal and plant species it presents to view, or studied in the relations of its present animals to the geological past, the Neotropical area equals, if, indeed, it does not in some features excel in interest, the great island-continent itself. The monkeys of the Neotropical region, for example, are totally different from those of any other region of the globe. They are broad-nosed, and usually possess prehensile tails,

adapting them for an active life amid the dense forests of the region. Those apes have no callosities; their thumbs are less perfectly developed than in Old World apes; and cheek-pouches are also wanting. They include (fig. 19) the spider monkeys, howlers, capuchins, marmosets, and many other peculiar and special forms. The bats are likewise peculiar, in that they are represented by the famous vampires and other blood-sucking species. The rodents are the chinchillas, the curious capybara, the pacas, and agoutis and tree porcupines, possessing, like the apes, prehensile tails. The carnivora include the racoons, which take the place in this region of the weasels of the Old World. Deer and llamas represent the ruminants of the region; and the tapir and peccaries represent other forms of hoofed quadrupeds. It is the group of the *Edentate* quadrupeds, however, which finds in Neotropical territory its peculiar home. If the marsupial kangaroos and wombats characterise Australia as their headquarters, no less typically in South America do the sloths, true ant-eaters (fig. 20), and armadillo (fig. 21) represent the fulness of Edentate development. With the exception of a few species of scaly ant-eaters or pangolins (fig. 22) occurring in the Ethiopian and Oriental regions, and the "aardvark" or ground hog of South Africa, the Edentate mammals are absolutely confined to the Neotropical region; and it is in the recent deposits of South America that we likewise discover the fossil remains of those huge extinct edentata, of which the *Megatherium*, *Mylodon*, and *Glyptodon* are well-known representatives. Last of all, the marsupial opossums, an apparent remnant of Australian life, find their home in the Neotropical area. As remarkable exceptions and absentees from the lists of South American quadrupeds may be mentioned the *Insectivora*, of which order—represented by

FIG. 20.—ANT-EATER.

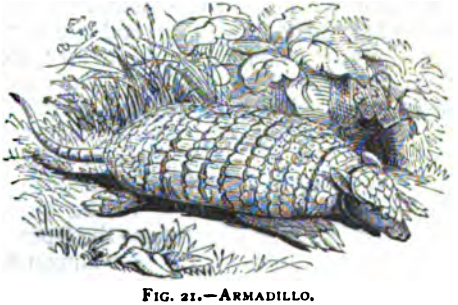

FIG. 21.—ARMADILLO.

the moles, shrews, and hedgehogs—not an example exists in this area, if we except a little shrew in the north, and one genus in the West Indian Islands. Then, also, we may note the absence of sheep and oxen; there are none of the civets, so widely spread over other areas; and there is an absence of the large carnivora, and of the elephants and rhinoceroses of the Old World.

Equally notable are the birds of the region. The smaller Passerine birds of the region, curiously enough, want the singing muscles of the larynx, as a rule. To this group belong the ant-thrushes, tree creepers, tyrants, chatterers, and manakins. Other typical birds of this area are the tanagers, toucans, puff-birds, todies, and mot-mots. No less typical are the macaws, the curious curassows and tinamous, the sun bitterns and the horned screamers; and the humming-birds are likewise among the veritable gems of South American ornithology. The humming-birds, ranging from Sitka to Patagonia, from the plains to the towering heights of the Andes, are absolutely confined to the New World. "No naturalist," says Mr. Wallace, "can study in detail this single family of birds, without being profoundly impressed with the vast antiquity of the South American continent, its long isolation from the rest of the land surface of the globe, and the persistence through countless ages of all the conditions requisite for the development and increase of varied forms of animal life." The curassows are distant relatives of the mound-birds of Australia, and the tinamous possess affinities with the ostrich-tribe itself; whilst in such peculiar Neotropical birds as the *Cariama* of Brazil, the sun bitterns and horned screamers, we see types of birds, either intermediate between other families, or standing solitary and isolated in the bird class, testifying again by these peculiarities of structure to the lapse of time which has passed since their evolution from some common and now extinct type.

FIG. 22.—PANGOLIN.

The snakes of the region are numerous and peculiar, and the lizards are equally varied. The true crocodiles and the New World alligators coexist in this region, and the tortoises attain considerable development in this region. The tailed newts are well-nigh absent, however; frogs and toads are abundant; and the fishes of South America present us with numerous types, many of the species

and 120 genera at least being confined to the waters of the area.

Central America, as might be expected, shows less clearly the characteristic features of the southern portion of the continent. There we find a commingling of Nearctic with Neotropical forms, but the latter predominate, and as far north as Mexico we may trace the howling monkeys and armadillos of the southern region.

In the case of the West Indian Islands, forming the *Antillean* sub-region of the Neotropical province, however, we meet with greater variations from the fauna of the continent. No better instance of the apparently arbitrary, but nevertheless logical and scientific, method of mapping off the earth's surface for biological purposes, could well be selected, than the zoologist's classification of the West Indian Islands. For, encircling Cuba, Hayti, Jamaica, Porto Rico, St. Vincent, Barbadoes, and many other islets in his biological line, he places outside this line Tobago, Trinidad, Margarita, and Curaçoa. The elimination of these latter islands from the "zoological" West Indies, whilst they form characteristic islands of the geographical Antilles, is readily explicable. Trinidad and its three neighbouring islands in their zoology differ entirely from the other West Indian Islands, but agree with the adjoining coast of South America in the character of their included animals and plants. Scientifically and zoologically, they are therefore parts of South America; they belong to the Brazilian sub-region, and not to the West Indian sub-province. Their affinity to the continent in the matter of their botany and zoology, and their wide divergence from the other West Indian Islands, point clearly to their relatively late detachment from the South American coasts. Their constitution as islands was attained, in other words, at a date much more recent than that at which the other islands of the group received their status as independent lands. Of Trinidad and its neighbouring islets nothing peculiar in a zoological sense can be detailed. We may, therefore, turn to the typical West Indies themselves.

Rich in vegetation and all that contributes to the support of animal life, the West Indies are poor in representatives of the higher groups. But they compensate the zoological mind for poverty in numbers by peculiarities of type. No apes or carnivora are native to the West Indies, and the characteristic edentates of South America —the sloths, ant-eaters, and armadillos—are likewise wholly absent. But bats are abundant, and the rodents are peculiar. *Capromys*, one of these rodents, inhabits Cuba, Jamaica; and *Plagiodontia* is found in Hayti alone. These two genera are thus exclusively limited to the West Indies. In addition, an agouti is found in St. Vincent, and other islands; and a rare species of mouse (*Hesperomys*) is found in Hayti and Martinique. If the West Indian rodents are peculiar,

so likewise are the Insectivora belonging to the curious genus *Solenodon*. Two species of Solenodon occur, one in Cuba, the other in Hayti. These animals are allied to the Madagascar "tenrecs." They possess an extremely elongated nose, a long and scaly tail, and powerful claws. The fur is coarse, and the teeth are peculiar in some respects.

The entire zoological history of the West Indian Islands tends to show their distinctness as a biological region. Their fauna bears a decidedly Neotropical character in its essential details, but it is likewise a fauna which has undergone extensive modification through a long separation from the ancient mainland of which these islands once formed part.

The biological divisions of the globe having thus been detailed, the task of investigating the causes which have wrought out the existing distribution of life on its surface yet remains. These preliminary studies form the material facts whereupon we may erect a solid hypothesis concerning the means whereby the living population of the earth has been modified, assorted, and arranged. We may accordingly marshal the facts in due order, that we may connect them by a theoretical bond—using hypothesis, thus legitimately, as a guide to the discovery of truth.

Having thus summarised the chief facts relating to the distribution of the higher animals on the surface of the globe, and having indicated the boundaries of the six great regions into which, from a consideration of the distribution of life, the biologist divides the land areas of the earth, we may now enter upon the consideration of the explanations which biology is prepared to afford of the facts in question. It is necessary to bear in mind the cardinal fact that only two theories are possible respecting the distribution of life on the earth; as, indeed only two explanations may be offered concerning any other cosmical phenomena, whether relating to the world of life or to that of inorganic matter. In other words, we must either assume, in the first place, with regard to the distribution of life, or to the origin of species itself, that a supernatural, and therefore inexplicable, fiat in the beginning of things, created each species separately and independently, and placed it directly or indirectly in its special locality or home; or, secondly, we may elect to believe, on the theory of evolution, that the varied tribes of living beings are the descendants of pre-existing species; that variation and modification constitute great and continuously operating factors in moulding the living form; that species extend or limit their range of habitat according to the facilities or obstacles presented by their surroundings; and lastly, that physical and geological changes of the earth's surface are continually operating and influencing at once the relations

of species, and the character and distribution of the life of any given area.

Such are the two hypotheses which now, as of yore, appeal for acceptance, as explanatory of the living universe and its constitution. The first theory is entirely dogmatic and theological in its terms. Stamped by the *imprimatur* of the churches, it commended itself in a readily understood fashion to the unscientific mind. An exercise of that unquestioning faith which the intellectual mind finds but chains and bondage in its endeavour to rightly interpret the facts of nature in their own light, is all-sufficient to establish the theory of the special creation of animal and plant species in their several localities, as a revelation of Supreme power. But the mind which accepts special creation dare not face nature. There is for such a mind no appeal to the external facts which surround it in the universe of life. There can be no intellectual analysis of belief in such a case; no intelligent questioning of the why and wherefore of the phenomena which the theorist endeavours to explain. The theory of evolution, on the other hand, finds its glory and its strength in its fearless interpretation of nature. There exists no peculiarity of life which it may not seek to explain. It is fettered by no considerations save those which foster reverence for truth, and which make for appreciation of the knowledge that "grows from more to more." Best of all, it has nothing to fear from the advancing tide of knowledge which itself has created and fostered; and it submits its deductions fearlessly and fully to every new light which the increase of research can direct upon them.

Sir Joseph Hooker has put the case of Evolution *versus* Special Creation in the most forcible fashion, when, in speaking of the origin of species, he says: "There are two opinions accepted as accounting for this: one, that of independent creation, that species were created under their present form, singly or in pairs or in numbers; the other, that of Evolution, that all are the descendants of one or a few originally created simpler forms. The first doctrine is purely speculative, incapable, from its very nature, of proof; teaching nothing and suggesting nothing, it is the despair of investigators and inquiring minds. The other, whether true wholly or in part only, is gaining adherents rapidly, because most of the phenomena of plant life may be explained by it; because it has taught much that is indisputably proved; because it has suggested a multitude of prolific inquiries, and because it has directed many investigators to the discovery of new facts in all departments of Botany." What Sir Joseph Hooker says of evolution in its relations to botanical science may be more than re-echoed by students of distribution. As already remarked,

the science of distribution has been actually created by evolution. Before the idea of the modification of species was ventilated, no science which could account for the diverse relationships of living beings in space was possible, because such explanation, on the theory of special creation, was not required. Only, therefore, on the hypothesis of evolution can any explanation of the distribution of life be attempted. It may be likewise added that, in the facts of distribution, the evolution hypothesis finds one of its strongest supports.

In 1605 appeared a curious work, entitled "The Restitution of Decayed Intelligence in Antiquities, concerning the most noble and renowned English Nation." The author—one Verstegen—informs his readers in one chapter of the reasons for believing that the "Isle of Albion" had been connected by "firm land with Gallia, now named France, since the Flood of Noe." One passage from this quaint work interests exceedingly the student of distribution. It runs as follows: "Another reason there is that this separation hath been made since the Flood, which is also very considerable, and that is the patriarch Noe, having had with him in the ark all sorts of beasts, these then, after the Flood, being put forth of the ark to increase and multiply, did afterward in time disperse themselves over all parts of the continent or mainland; but long after—it could not be before—the ravenous wolf had made his kind nature known to man; and therefore no man, unless he were mad, would ever transport of that race out of the continent into the isles, no more than men will ever carry foxes (though they be less damageable) out of our continent into the Isle of Wight. But our Isle, as is aforesaid, continuing since the Flood fastened by nature unto the Great Continent, these wicked beasts did of themselves pass over. And if any should object that England hath no wolves on it, they may be answered that Scotland, being therewith conjoined, hath very many; and so England itself some time also had, until such time as King *Edgar* took order for the destroying of these throughout the whole realm."

That which to the contemporaries of Verstegen, as to many persons ignorant of the teachings of geology even in our own day, would seem a wild impossibility—namely, the junction of England and France by land surface—is known to the tyro in geology to have been a plain reality. Convulsions and disconnections, as well as elevations and connections of land surfaces, are among the most familiar facts of geological science, which views the land as an ever-shifting quantity amid the factors of physical change.

A brief allusion to some of the more familiar instances in which the association or connection of land surfaces serves to account for a likeness of the contained life, may demonstrate that the author of "The Restitution of Decayed Intelligence in Antiquities" was, in his

day and generation, groping successfully enough after the true cause of the likeness between the animals of Albion and Gaul. In the Neotropical region of the geologist, the Island of Trinidad presents us with an excellent example of the bearing of geological change over the distribution of life. Geographically, Trinidad is one of the West Indian Islands; zoologically, Trinidad is a part of South America. Whilst the animals of the West Indian Islands are highly peculiar, as we have seen, those of Trinidad resemble the animals found in the neighbouring American area; and along with Trinidad we may class the islands of Tobago, Margarita, and Curaçoa as zoologically belonging to the South American continent, and not to the Antilles. Close to Trinidad lie Grenada, Barbadoes, and St. Vincent; yet the geographical nearness of these three latter islands to Trinidad is completely overturned by the facts of distribution. What theory of the constitution of living beings and of the earth at large is competent to explain the immense differences which separate Trinidad and neighbouring islets in a zoological sense from the Antilles? On the theory of special creation, no explanation is possible. On the hypothesis of evolution, the main outlines of the problem and its solution are clear enough. The relations of Trinidad and South America are in reality the counterpart of those which Verstegen assumed existed between the "Isle of Albion" and Gaul. At a relatively and geologically "recent" date, there was land connection between Trinidad and the American continent—such is the geological phase of the question. The biological aspect shows us a sufficient reason for the likeness of the fauna of Trinidad to South American life, by assuming that the processes of variation and change in its species have not yet had time sufficient at their disposal to establish differences of importance. Conversely, the Antilles form, as we have seen, a highly peculiar region for the opposite reason—namely, that these islands, once united to Central America, became detached at a remote period. This ancient separation prevented the inroad of the higher and later forms of life, whilst it would specialise and intensify the characters of the forms which these islands originally claimed as their own.

The case of other islands presents equally and in some cases even more notable and characteristic examples of the influence of isolation from or, conversely, of long-continued connection with continents upon the included life. Very interesting is it to note the extreme differences which prevail between the islands of Bali and Lombok in the Eastern Archipelago, each island being as large as Corsica. They are separated by the Straits of Lombok, which are about fifteen miles in width at their narrowest part. Despite the narrowness of this channel—which, however, bears evidence of its antiquity in its great depth—these islands differ far more widely in

the character of their animals and plants than do Britain and Japan. On the Australian side of the straits we find Lombok, the outpost, so to speak, of the strange Australian land that lies beyond. On the Indian side lies Bali, essentially identical with the other islands of the Archipelago in the life which has already been described. Does the theory of special creation give any rational explanation amongst its tenets for this extraordinary dissimilarity between two apparently adjacent islands? Or, if we look in vain for such explanation from the side of special creation, does the theory of evolution, which postulates the long separation of Bali from Lombok as the primary cause of the divergence of their respective fauna, offer a satisfactory solution of the problem? There can be no hesitation in our choice of explanations; since, whilst the former hypothesis presents only a speculative faith as the reason of its being, the latter is founded upon geological facts, and upon evidence derived from the distribution of life at large.

Again, in the Oriental region, and within the limits of the Eastern Archipelago itself, we may meet with abundant instances of the same great truth, that the long isolation and separation of any land, however limited or however extended its area, must entail a corresponding divergence and specialisation of its included animals and plants. The history of islands becomes, in this view of matters, especially instructive to the naturalist. Java, Borneo, and Sumatra are thus regarded in a geographical sense as being nearly connected. Java and Sumatra are geographically near, whilst Borneo is more remote from the two former islands. But, curiously enough, whilst Borneo is thus removed from the vicinity of Sumatra, its included life resembles that of Sumatra, whilst the animals and plants of these two islands taken together, differ materially from those of Java. Thus, whilst at least 13 genera of quadrupeds are known to inhabit two or often three of the other Oriental areas—Borneo, Sumatra, and the Malay Peninsula—these genera are absent from Java, and they include, as Mr. Wallace remarks, such typical forms as the elephant, tapir, and Malayan bear. There are 25 genera of birds found as a rule in Sumatra, Borneo, and the Malayan peninsula, which are yet absent from Java; these birds including the jays, gapers, hornbills, cuckoos, pheasants, partridges, and other equally familiar forms A second fact of importance in considering the relations of Java to its neighbour islands consists in certain marked similarities which its animals are known to present to the Asiatic Continent. The mammals and birds of Java, in a word, "when not Malayan, are almost all Indian or Siamese." How, then, are these two series of facts to be accounted for? How are we to explain, firstly, the dissimilarity of Java from Sumatra and Borneo, and its likeness to Indian and Siamese in respect of its included life? Again we appeal

to the facts of geological change for a solution of the difficulties in question. If we suppose, firstly, that Himalayan species, driven southwards by climatal or other changes, found a home in Java; and, secondly, that the separation of Java from the adjoining lands took place long prior to the isolation of Borneo and Sumatra from the Malay peninsula, we may fully account at once for the persistence of Asiatic animals in Java, and for its differences from Borneo on the one hand and Sumatra on the other. In such an explanation, let us note, we must likewise take the facts of organic variation, producing change and modification of species, into account. The peculiarities of the Philippine Islands, which were separated in their turn earlier than Java from the mainland, can be accounted for on the same principle of isolation, entailing a corresponding modification of the life of any area.

No less interesting is the history of such islands as the Azores, and Galapagos, which represent "oceanic" islands, never connected with a continent or large land area; or the history of such isolated lands as the British Islands, which are clearly of "continental" origin, and which once formed part of the larger land area to the south and west: whilst such islands as Madagascar or New Zealand present us with an instance of specialised land surfaces, whose connection with continents is a thing of the very remote past. A reference to each of these islands will serve to establish more firmly and clearly in the mind the high importance of physical change as a paramount condition in determining the distribution of life on the globe.

The Azores and Galapagos islands are typically "oceanic." San Miguel, in the Azores, is 900 miles from the coast of Portugal as the nearest continental area; whilst the Galapagos are about 600 miles from the west coast of South America. In these islands we see exemplified the characters of "oceanic" islands. They are volcanic in nature, and represent rock masses upheaved from the sea-depths. As in oceanic islands, at large, there are no native quadrupeds, and none of the frog or toad class (*Amphibia*). In the Azores there is not a single native, terrestrial vertebrate animal—no snake or lizard being found in addition to the already specified omissions; and no fresh-water fishes exist. The rabbits, weasels, rats, and mice of the Azores, and a single lizard, occurring in Madeira and Teneriffe likewise, are all importations; and of the eels and gold-fish in the lakes of the Azores, the same opinion may be expressed. Birds, land-shells, and insects constitute the animal population of these islands. Of 53 species of birds, 31 are waders or swimmers; and whilst 20 aquatic birds are residents, 18 of the land birds are permanent tenants. With three exceptions, the 18 land birds, however (including the quail, robin, barn-owl, starling, wood-pigeon, &c.), are common in Europe and North Africa; the exceptions being the Atlantic

chaffinch and the canary of the Madeira and the Canary Islands, and the peculiar Azorean bullfinch. There are no difficulties in the way of accounting satisfactorily for the existence even of these latter species. The bird-population of the Azores, as a whole originated in the storm-driven or chance stragglers from other lands. The oriole, snow-bunting, and hoopoe even now are occasionally found in the Azores; and as the birds are most numerous in the eastern islands of the Azores, Europe and Africa may be assumed to be the chief sources of supply of the bird-emigrants. The bullfinch of the Azores is, however, peculiar as well as interesting in its history. This bullfinch is a marked variety of the European species, just as other Azorean birds exhibit slight divergences from our own species. We see in this bird, in fact, the beginning of that work of modification, induced by the influence of new locality on the species, to which is due the endless variety of the earth's population as a whole. The insects and land-shells of these islands present clear traces of European relationship; and the botany of the Azores, showing us 480 various species of flowering plants and ferns, also declares that 440 of these species occur in Europe. Even of the forty peculiar species of plants, all, save six, find a near relationship in European plants; and these six are related to the plants of the Canaries and Madeira. Like the birds, the land-shells, insects, and plants have reached the Azores as emigrants from the adjacent continents and islands. Means of dispersal and conveyance are abundant; and Darwin has shown how common are the methods whereby the lower and occasionally the higher forms of animals and plants can be distributed often to vast distances from their original home. Let us for a moment consider some of these casual or accidental means of dispersal.

Many seeds will, for example, resist for lengthened periods the action of sea-water. Out of 87 kinds of seeds, 64 germinated in Mr. Darwin's hands after twenty-eight days' immersion; and a few survived after 137 days' immersion. Ripe hazel-nuts, when dried, floated for ninety days, and then germinated; and "an asparagus-plant with ripe berries floated for twenty-three days; when dried, it floated for eighty-five days, and the seeds afterwards germinated." There is thus ample time and opportunity, so far as the vitality of many seeds is concerned, to enable them to be transported safely by ocean-currents to far-distant shores. Seeds are, again, often carried impacted in the earth of floating roots of trees; and, as Darwin remarks, even the seeds of plants taken from the crops of dead birds floating on the surface of the sea, germinate when planted. Peas and vetches, "taken out of the crop of a pigeon, which had floated on artificial sea-water for thirty days, to my surprise," says Darwin, "nearly all germinated." Living birds,

next, act as efficient transporters of seeds. The hard seeds of many fruits pass uninjured through the digestive system of birds, and germinate thereafter. Even when a bird, containing seeds in its digestive system, has been swallowed by a hawk or other bird of prey, the seeds may be preserved intact during this double intussusception, and, on being disgorged by the flesh-eater, may germinate. "Seeds of the oat, wheat, millet, canary, hemp, clover, and beet, germinated after having been from twelve to twenty-one hours in the stomachs of different birds of prey; and two seeds of beet grew after having been thus retained for two days and fourteen hours." As regards insects, locusts, says Darwin, "may be blown to great distances from the land." A locust was caught 370 miles from the coast of Africa. In November 1844, a swarm of locusts visited Madeira, and Darwin remarks that, as from locust-dung he extracted the seeds of seven grass plants, "a swarm of locusts such as that which visited Madeira, might readily be the means of introducing several kinds of plants into an island lying far from the mainland." More curious still is it to discover a means of plant-dispersal in the earth which adheres to the beak and feet of birds. From the leg of a woodcock, a little cake of dry earth weighing nine grains was removed by Mr. Darwin. In this earth a seed of the toad-rush was contained, and this seed germinated. From the seeds contained in the earth adhering to the leg of a partridge, which had been kept for three years, Mr. Darwin obtained 82 plants. "With such facts before us," says Mr. Darwin, "can we doubt that the many birds which are annually blown by gales across great spaces of ocean, and which annually migrate—for instance, the millions of quails across the Mediterranean—must occasionally transport a few seeds imbedded in dirt adhering to their feet or beaks?" The agency of icefloes and icebergs, which are frequently laden with earth, and which have been known even to transport the nest of a land bird, must likewise be considered as a means whereby transport of arctic and antarctic species may have occurred. We must lastly add to these artificial methods of plant-dispersal, the natural means which exist in many plants for the diffusion of their offspring. Winged seeds and fruits are by no means uncommon; the *pappus* or down of the dandelion and other *Compositæ* present familiar examples of natural contrivances for securing a wide distribution of their seeds; there are some flower-heads (*Acæna*) which adhere to the fur of animals or to the feathers of birds like our familiar "burrs"; and other plants, again, possess more special contrivances still for securing their adhesion to the animal integument.

The dispersal of animals in the same way is accomplished by natural and casual means. The power of flight and of swimming illustrate the former; whilst the conveyance of an animal on drift-

wood, or the chance dispersal of their eggs by other animals or upon plants, exemplify the accidental methods of diffusion. The minute eggs of fishes have been known to adhere to the plumage of aquatic birds; even water-insects may transport fish-ova. The young of shell-fish, like the cockle and oyster, at first swim freely in the sea, and may migrate to vast distances; and certain shell-fish (*e.g.* fresh-water snails) deposit their eggs upon aquatic plants, which may likewise be conveyed for many miles by currents. That the feet of aquatic birds may convey minute or embryonic shell-fish to great distances is rendered probable by observations of Mr. Darwin; and the same high authority remarks on the agency of aquatic birds in conveying seeds which are contained in the mud of ponds adhering to their feet. With regard to the dispersal of insects, the power of flight is seen to confer obvious advantages upon this class of animals. Even quadrupeds appear to possess occasional powers of dispersal, which may account for their presence in situations that at first sight would seem inaccessible to the race. The tiger is known to be a powerful swimmer; and the pig, popularly credited with being inefficient in the water, has been proved to be a swift swimmer likewise. Quadrupeds may also be conveyed long distances on driftwood, and may thus chance to be deposited in localities far removed from their original habitat.

There is little difficulty in accounting for the mechanical means and conditions whereby the dispersal of animals and plants is secured. Hence, returning to the question of island-population, we find in the Azores a collection of animals and plants, obviously derived from adjoining areas, and which has as yet had but little time to develop, through variation, a general distinctness of its own.

The Galapagos Islands present, as we have seen, the common features of "oceanic" islands, in the absence of native quadrupeds and amphibians, and in the fact that they are of volcanic origin. They differ from the Azores, however, in that they possess two species of snakes, lizards, and land-tortoises—the latter being of large size. A single mouse exists in these islands; but this quadruped belongs to an American genus, and was probably introduced, since these islands have been largely visited for 300 years back by sailors. The tortoises are regarded as having been derived from the American continent, and the lizards, of which there are five, are likewise typically American in their character. That tortoises and lizards can travel for long distances by water cannot be doubted; and the fact that snakes occur in the Galapagos, and may have reached these islands by swimming—seeing that they are related to South American serpents—is explained by the knowledge that snakes may swim for long distances. A boa-constrictor has been known to swim to St. Vincent from the South American coast, a distance of at least 200 miles. The birds

of the Galapagos number 57 species—38 species being peculiar to the islands. But the study of the birds is rendered extremely interesting by the fact that we notice amidst their ranks all shades of likeness and divergence from continental forms. Some species are identical with American birds, whilst others are different from well-nigh all other bird forms. Thus there is the rice-bird of Canada and the United States remaining unchanged in the Galapagos Islands; whilst the short-eared owl, which, as Mr. Wallace says, "ranges from China to Ireland," evinces a slight variation in its Galapagos form from the familiar home bird. The finches and sugar-birds of the Galapagos exist as distinct genera, and represent forms which, restricted in range even in South America, have kept their chief peculiarities intact, and have developed others sufficiently distinct to render their race peculiar to these islands. Casual migration, along with a comparatively undisturbed residence in these islands, together explain the distinct character of the bird-population, as well as of the lower denizens of the Galapagos.

If the effects of land-separation and isolation are typically witnessed in the case of the "oceanic" islands, the opposite results of recent land-connections with continental areas are seen in the history of the "continental" islands. Of these islands Great Britain and Ireland form typical examples, as likewise do Japan, Borneo, Java, and other areas. The "continental" islands evince a close connection with the mother-land in the usually shallow sea—not as a rule exceeding 100 fathoms in depth—which separates them from the continent. They possess quadrupeds and reptiles, and these animals, along with the remaining fauna, exhibit, as a rule, a close likeness to the life of the larger area. All around the British Isles the 100-fathom line persists, and joins Britain to Denmark, Holland, Belgium, and France, as well as to Ireland on the west. The geological proofs of our "recent" union with the continent are numerous and indisputable. Probably after the greatest intensity of the glacial epoch, Britain joined the continent for the last time; and as our quadrupeds are identical for the most part with those of France and the continent, there can be little hesitation in endorsing the geological opinion from the zoological standpoint. Possibly submergence after Britain received its continental migrants, may account for our paucity of species, when compared with continental life; this subsidence destroying and limiting what would otherwise have been an abundant fauna. For we discover that whilst Belgium has 22 species of reptiles and amphibia, Britain possesses but 13, whilst Ireland has but 4 species—this latter result being due to the depth of the Irish Sea, which is greater than that of the German Ocean: a fact pointing to the more remote separation of Ireland, as compared with the continental connections of Britain. Our islands possess, it must be remarked,

certain peculiar birds ; they are rich in peculiar fishes, and probably in mosses of special kinds as well. But whilst these peculiarities point to the existence of conditions which favour specialisation of form, they do not in any sense oppose the idea—strengthened into absolute fact by all the considerations of geology and biology—namely, that at no remote date, but "recently" in a geological sense, the "land of the free" itself had no special identity of its own, and that all its future individuality was merged in its continuity with the great continental area around.

A brief reference to the peculiarities of Madagascar and New Zealand may serve to conclude our reflections on islands and detached land areas, as illustrative of the geological factors which regulate the distribution of life on the earth's surface. The peculiarities of New Zealand as a biological province have already been discussed. Its want of native mammals and snakes, its single frog, its peculiar lizard, and its living and extinct wingless birds, as well as certain characters of its plant-life, mark it out as especially peculiar. No less specialised and peculiar, on the other hand, is Madagascar, the zoology of which has likewise been described. The differences of its animals from those of the African continent; its peculiar lemurs ; its special insectivora and carnivora, and rodents ; and its other biological features, render this great island a highly specialised part of the world's surface. New Zealand and Madagascar stand out prominently before us as examples of "ancient continental islands." That "once upon a time" they formed part of a continental area, no one may doubt ; but that their separation has been so remote as well-nigh to justify the appellation of "oceanic" islands, is also a logical deduction from their biological history. In Madagascar and New Zealand are beheld, in a word, the effects of isolation, which, depending in turn upon geological changes and the submergence of land, gives to the latter agencies their great power in modifying the life of the globe. "Such islands," says Mr. Wallace, "preserve to us the record of a bygone world—of a period when many of the higher types had not yet come into existence, and when the distribution of others was very different from what prevails at the present day." It is in islands such as Madagascar and New Zealand, that we see preserved to us the remnants of a fauna that may once have been of world-wide extent. Mr. Wallace, again, remarks that "A partial subsidence will have led to the extinction of some of the types that were originally preserved, and may leave the ancient fauna in a very fragmentary state ; while subsequent elevations may have brought it so near to the continent that some immigration, even of mammalia, may have taken place. If these elevations and subsidences occurred several times over, though never to such an

extent as again to unite the island with the continent, it is evident that a very complex result might be produced; for, besides the relics of the ancient fauna, we might have successive immigrations from surrounding lands, reaching down to the era of existing species." Thus, in the life of Madagascar, we see the results of isolation interrupted by periods of connection with large continental areas. The fact that the lemurs of Madagascar exist likewise in West Africa, in the Indian region, Ceylon, and the Malay Archipelago, is explicable—not by supposing a direct land-connection occupying the site of the Indian Ocean—but by regarding these animals as presenting us, in Madagascar, with the remnants, secured from harm by isolation, of a once widely distributed lemur-population. This group of animals, doubtfully classified to-day as the lowest order of the monkey-tribe, as we know from the evidence of fossils, overran Europe in the Eocene period of geology. We know that Africa was separated from Europe and Asia in the Tertiary period by a large sea-area. Thus, late in its history, were outlined the bounds of the Ethiopia which the biologist has defined, and which, as we have seen, has the desert region as its northern and natural boundary. Joined to Africa in its earlier phases as an island, Madagascar doubtless received from Africa the lower quadrupeds, reptiles, insects, and other forms bearing evidence of a distant Australian or New World relationship. Then came the separation of Madagascar from the African continent—a phase of its history which left that island to mature and develop the modified and peculiar species we see within its limits to-day. At the same time this separation protected it from the inroads of the higher animals coming from the north, which we now find amongst the existing African fauna.

Similarly, the problem of the likenesses and differences between the life of New Zealand and Australia are explicable only upon the idea—supported by strong geological evidence—of land changes of curious and complex character. Thus Eastern Australia must have been separated from Western Australia in the Chalk period; and whilst New Zealand was connected by shallow water with tropical Australia, it was sharply demarcated from temperate Australia by a deep sea. Thus is explained the fact of the plants which are common to Australia and New Zealand being tropical and sub-tropical in their nature. Direct land-connection between the two countries, but a connection which at the same time was anything but equivalent to continuity with existing Australia—seeing that the latter was practically halved in the Chalk period—explains the means whereby the underlying likeness between the life of these islands was established.

By way of establishing still more firmly the truth of the axiom that physical change forms one of the two main factors involved

in the regulation of life and its distribution, we may lastly glance at the history of that peculiar race of quadrupeds, the *Marsupials*, or "pouched" mammals, in their relations to Australia as their headquarters and home. These animals, possessing the kangaroo as their most familiar representative, are, with one exception, confined to Australia, along with certain other and lower quadrupeds, such as the *Ornithorhynchus* and *Echidna*. The exception to the rule that the two lowest orders of quadrupeds are confined to the Australian region is the opossum family (*Didelphidæ*), which occurs in the New World. Bearing in mind the facts that, firstly, save a few recently introduced bats and a rodent or two, Australia has no native mammals of higher grade; that, secondly, the kangaroo and its neighbours represent in that land the fulness of quadruped life elsewhere; and that, thirdly, save the opossums, those animals are absolutely confined to Australia,—how, it may be asked, are these peculiarities to be accounted for? If the theory of special creation be appealed to, it would find it necessary to insist, in virtue of its own terms, that the marsupials were created where we now find them. Such a theory, however, supplies no intellectual reason why the opossum, a typical enough marsupial, should have been created in the New World, and thus have been left mysteriously and arbitrarily outside the limits of the Marsupial or Australian territory. Let us endeavour to ascertain what explanation of these apparently anomalous facts the science of distribution can afford.

Firstly, from the geological side comes the evidence that Australia has never possessed, at any time, any native quadrupeds of higher type. All the fossil remains of the Tertiary and Post-Tertiary age discovered in Australia are those of Marsupials, often of giant size, but still allied to the existing quadrupeds of the region. But geology opens up a new vista of thought before us when it reveals the fact that in the earliest Tertiary period Marsupials occurred in Europe, these being the remains of opossums. In older deposits—that is, in the Oolite and Trias—of Europe, occur the remains of Marsupials, some of which are well-nigh identical with the little banded ant-eater (*Myrmecobius*) occurring in the Australia of to-day. Passing to North America, we discover in the Triassic rocks of that continent the *Dromatherium*, likewise an ally of the living ant-eater of Australia. So far, therefore, from Marsupials having mysteriously sprung into being in Australia, we discover that in Triassic times they existed not only in Europe but in North America, and that, in fact, they may be regarded as having possessed a wide Palæarctic range in that period and in its succeeding Oolitic epoch likewise.

Let us note, again, that the marsupial and allied quadrupeds resembling the ornithorhynchus were the oldest and earliest in time, as well as the lowest in structure. The problem of the origin of the Australian

quadrupeds and of their distribution is not now difficult of solution. We pass backwards in imagination to the Triassic and Oolitic times to behold, then, the dawn of mammalian life. We see the Marsupial tribes representing, in the ancient Palæarctic region, the fulness of the quadruped life that was afterwards to dawn. No higher form of mammalian existence was then to be seen. The carnivora and rodents, the bats and apes, the hoofed quadrupeds, and the variety of mammalian life that marks our day, was as yet unknown. But Australia at this period is in geographical connection with the Asiatic continent. Over a continuous land surface, these earliest quadrupeds pass to people the Australian territory. Next comes the separation of Australia from Asia. The Malay Archipelago represents the broken and divided land-connection, first severed probably at the Straits of Lombok. The higher tribes of quadrupeds are evolved from the lower tribes in the ancient Europeo-Asiatic continent. The defenceless lower Marsupials are worsted in the "struggle for existence" that ensues. The higher "tooth and claw" exterminate the lower races in the Palæarctic region; but in Australia the isolated, these Marsupials, free from the irruption of later carnivores with tooth and claw, and protected by the intervening sea from the inroad of the higher quadruped-races, flourish and grow. As time passes, the original species of Marsupials—that is, the first emigrants to Australia—vary, and, through variation, produce new races and species of these quadrupeds. Australia in due time develops a quadruped population of its own, which repeats the varied features of mammalian existence elsewhere. Thus again there is presented to our view an illustration of the double work of land alteration and specific or biological change, in developing a strange and wondrous population on the surface of the earth.

Last of all, the history of the opossums and their distribution, now limited to the New World, falls under the sway of the same efficient explanation, supported by every fact of life and by all the details of geological science.

Commencing their existence in the Palæarctic region—their fossil remains occurring, for example, in the Eocene rocks of France—the opossums represent a race which never at any period of their existence have dwelt in Australian territory. Their occurrence in America is explicable, not on any theory of possible connection between America and Australia, but on the plain hypothesis of their migration to the New World by a continuous land surface in the middle or towards the end of the Tertiary period, from Europe or from Northern Asia as a centre. Their earliest fossils, in the New World, occur in the American Post-Pliocene—that is, long after their first appearance in European formations. Passing thus to the New World, the opossums migrated southwards, where they flourished

and grew apace, comparatively unmolested by carnivora or other enemies. Again extending their range northwards, they are found in North America ; and they thus represent in the Western Hemisphere a flourishing remnant of a race killed off from the Old World, and driven, by stress of outward circumstances, to seek refuge in the New.

Not less interesting is it to find that the existing life of Australia at large fully endorses the biological dictum that in this island territory we find still represented the life which was once world-wide in its extent in the Triassic and Oolitic period, in which period Australia severed its connection with the Asiatic continent. As the marsupial quadrupeds of the Oolite overran the existing land area of that day, so they flourish, and flourish alone, in the Australia we ourselves know. As the spine-bearing Port Jackson shark swims in the Australian seas to-day, so the spiny fishes *Acrodus* and *Strophodus* swam in the Oolitic seas that washed Palæarctic and other coasts. As the shell-fish *Trigonia* lived in the seas of the Stonesfield Slate period around our shores, so that *Trigonia* still persists on the Australian coasts alone. And, lastly, as the Araucarian pines and cycads grew in Oolitic times in our own area, so they grow now in Australian territory—a remnant, like the quadrupeds and fishes, of a flora and fauna once well-nigh universal, but now limited to the region of the earth wherein alone the original conditions of their life are truly represented.

If geological change isolating or uniting land areas, and the variation and modification of species consequent upon such separation or union, be thus credited with constituting the great factors and powers which have produced the existing distribution of animals and plants, and which have regulated that distribution in all time past, we may now briefly glance at the main features which the great biological regions of the world have exhibited in relation to the changes and alterations of their boundaries they have from time to time undergone.

Whilst the late Sir Charles Lyell and other geologists were found not so long ago to declare that the great continents of the world " shift their positions entirely in the course of ages," a clearer understanding of geological evidence has completely established the doctrine of the permanence of the great continental areas, and of the general stability in time of the main masses of the land. It is needful to make ourselves acquainted with this fact, inasmuch as, if the distribution of life depends primarily on the distribution of land and sea, a clear understanding of the agencies regulating the development of animals and plants on the globe will be gained only when the physical changes in question are duly appreciated. The geological evidence, then, goes to prove that, whilst the general mass of the

continents has remained unchanged, their minor features and more intimate details have been subjected to frequent disturbance. Thus in the past, as at present, the uniformity of geological action postulates the work of rivers in eroding the land, of the sea in defacing the coasts, of ice in carving the land surface, and of volcanic action in depressing this area or elevating that, and in causing the sea to flow here, or to repress its march there. Professor A. Geikie maintains that the stratified rocks, instead of being formed in the beds of deep oceans, "have all been deposited in comparatively shallow water." And, again, this eminent geologist remarks of the manner in which this earth's materials have been formed, that "From all this evidence, we may legitimately conclude that the present land of the globe, though formed in great measure of marine formations, has never lain under the deep sea; but that its site must always have been near land. Even its thick marine limestones," adds Professor Geikie, "are the deposits of comparatively shallow water."

Thus with the proofs of the general permanence and stability of our great continents at hand, we can completely account for all the plainer facts, and for many of the difficulties, of distribution. For example, we infer that about the middle of the Tertiary period, Europe and Asia, as at present, formed one continuous land surface, which contained as its inhabitants the elephants, rhinoceroses, giraffes, apes, and other forms now found only in the Oriental and Ethiopian regions. Antelopes were then found in Southern Europe, and the giraffes extended from the South of Europe to the North of India. But we must likewise take account of those more intimate changes of land and sea which accompanied the general permanence of the continents. At the time we are considering, Africa south of the Desert was a large island; India and Ceylon were isolated by sea from Asia; Northern Africa was united to the South of Europe; Asia Minor was joined to Greece;—the outlines of the great zoological regions of the Old World were, in short, actually mapped out in the middle of the Tertiary period in the then existing lands and seas. But neither the detached India nor the isolated Africa possessed the abundant quadruped life of Europe and Asia. They possessed only the lower life of the Eocene time. When, however, the next series of physical alterations took place, when land passages arose between Europe and Asia together on the one hand, and Africa and India on the other, the higher quadrupeds migrated to these areas. There some adapted themselves to their new conditions, and flourished in their new localities, whilst others succumbed to the more rigorous surroundings which faced them. The antelopes, for instance, migrating to Africa, flourished in Ethiopia, because there they found a plentiful vegetation and the other conditions of life calculated to produce the development of new species

by the modification of the old. The bears and deer are unknown in Africa, on the contrary, since they were later comers in European territory, and because they found migration a difficult or impossible task. The fauna which Europe then gave to Ethiopia was killed off in the former by the climatal changes which succeeded these Miocene times, and which left the region to be peopled after the glacial cold, by the hardier forms which we now call our representative animals. Similarly, India as the Oriental province possessed when detached from Asia its own lower Edentates, and its lemurs; but when it became united with the Asiatic continent, it received from the north, like Africa, its new complement of animals—its monkeys, tigers, elephants, and other forms—these animals arising in the ancient Palæarctic land, whence, as we have seen, the earlier marsupials themselves migrated to people the other quarters of the globe.

The history of the New World is equally instructive, both as regards the proofs it supplies of the permanence of the continents, along with the evidences of the same laws of dispersal and migration of life which the consideration of the Old World areas affords. The first fact of importance in the scientific history of the New World areas consists in the knowledge that in the Post-Pliocene times the life of the Nearctic region approached very closely to that of the Palæarctic province. In the Post-Pliocene formations of America, we find the fossil remains of numerous carnivora, horses, camels, bisons, and elephants. Of the living elephants, as we have seen, the existing New World knows nothing. The horses were reintroduced by man; whilst the buffalo certainly represents the bisons, and the llamas similarly represent the camels. Before the Post-Pliocene time, geology reveals that America possessed rhinoceroses, special forms of ruminants, and a porcupine decidedly of Old World type. In the still earlier Miocene period, North America had its lemurs—now limited to India, Africa, and Madagascar—many carnivora, camels, deer, and tapirs. Earlier still, that is, in the Eocene period, there lived in North America animals unlike any forms now existent. There were the Tillodonts and Dinoceratidæ of Professor Marsh, which appear to have united in themselves the characters of several distinct orders of quadrupeds. There is thus every reason to believe that in the Post-Pliocene period, at least, and in earlier times likewise, there was free land communication between the Palæarctic and Nearctic areas. So that it requires no stretch of hypothesis to assume that the horses, camels, elephants, and other quadrupeds of America—proved to be near allies of European fossil forms—must have freely intermingled with those of Europe. That Europe, or, more properly, the Palæarctic region, must have been the original source whence the Nearctic land obtained its mastodons, porcupines,

deer, and other quadrupeds, is proved by the fact that these animals are known to have lived and flourished in Europe long before they occurred in America. So that, as Mr. Wallace puts it, "As the theory of evolution does not admit the independent development of the same group in two disconnected regions to be possible, we are forced to conclude that these animals have migrated from one continent to the other. Camels, and perhaps ancestral horses," adds Mr. Wallace, "on the other hand, were more abundant and more ancient in America, and may have migrated thence into Northern Asia." The physical difficulties of such a land connection at Behring's Straits or across Baffin's Bay, are not, it may be remarked, by any means insuperable.

Then, likewise, we must take into account the share which South America, or the Neotropical region, has had in influencing the distribution of life in the New World at large. North America seems in the Post-Pliocene epoch to have been a literal focus wherein Palæarctic life commingled with life from the South. Thus the North American Post-Pliocene deposits give us sloths and other forms of Edentate mammals, llamas, tapirs, and peccaries, all of which are typically South American; whilst some are identical with living Neotropical species. The bone-caves of South America show us that this region, like Australia, possessed in Post-Pliocene times the same description of quadruped life that now distinguishes it. As giant kangaroos lived in Australia, so gigantic sloths and armadillos lived in South America; and its chinchillas, spiny rats, bats, and peculiar monkeys were likewise existent then as now. In addition, we find that, as North America possessed its peculiar groups of lower quadrupeds in its tillodonts and other forms, so South America likewise had its special types of life, such as the *Macrauchenia*, resembling the tapirs, and the *Toxodonts*, related at once to the noofed quadrupeds and to other groups. But, whilst the quadruped immigrations into North America likewise affected South America, it must be borne in mind that the isolation and separation of South America from the northern part of the continent, as indicated by its regional distinctness, must have largely influenced the development of its own peculiar life—just, indeed, as the peculiarities of North America are due to its separation, in turn, from the Palæarctic area. And when we further discover the all-important fact that the fishes on each side of the Isthmus of Panama are identical, the theory of the relatively recent continuity of sea at this point, and the consequent separation of Neotropical from Nearctic land, rises into the domain of fact. Thus we see in North America a region which has repeatedly received and exchanged tenants with the great Europeo-Asiatic continent; which has, in consequence, developed a close resemblance to the life of the Palæarctic region; and which

has, likewise, been to a slight extent modified by the migration northwards of southern forms. In the life of South America we perceive, on the other hand, the results of longer isolation and greater specialisation. There the development of special forms of life has accordingly progressed to a much greater extent than in North America; and the effect of a commingling of types has been largely prevented by its relatively recent junction with Nearctic land. As in Australia the lower types of quadruped life have been preserved by the isolation of that area, so in South America the preservation of the sloths, armadillos, and ant-eaters, and the development of special forms of monkeys and other quadrupeds, are to be regarded as the fruits of that separation which secures protection to lower and comparatively defenceless life.

A glance at some of the difficulties of distribution, and a reference to the influence of migration upon the distribution of life, may draw our consideration of this topic to a close. The progress of any science from the stage wherein it formulates its beliefs in theory, to that when its theories rise through cumulative proof into the higher region of fact, is not accomplished without trial and tribulation. Criticism, destructive and constructive, is the lot of every scientific theory. But the earnest and unbiassed mind welcomes the criticism wherein the trial of its beliefs is contained, as the honest mind gauges the tenability of its beliefs by the residue, large or small, of solid fact which it is able to collect after the critical assault upon its stronghold is overpast. Of the science of distribution it may be said that its evil days are fairly past. Critics it has had, and biological opinions may even now be found to differ regarding the minor details of its constitution. But the larger and more fundamental propositions of distributional science remain untouched. They have passed out of the sphere of discussion, and have taken their place amongst the stable facts of the scientific system. It is necessary, however, to detail one or two examples of the difficulties which may still disturb the complexion of the scientific mind, and which are ever welcome to the devotees of a science, since they afford the means whereby the weak points and the unsettled problems of the science may be strengthened and solved.

Of such difficulties, then, let us specify a few instances, by way o showing how readily their solution may, through careful consideration, be obtained. Mr. Sclater has specified in a highly distinct manner a few of the knotty points that await the student of distribution, and has thus afforded opportunity for the discussion of the subject, and for their explanation or modification by the exercise of scientific acumen and research. Taking the case of the lemurs—those curious quadrupeds usually classified as lower monkeys—we are presented with certain apparent anomalies in their distribution

over the surface of the globe. Thus the lemurs have their headquarters in Madagascar, as already remarked, but they also occur in the Eastern Archipelago. They are scattered, to use the words of Mr. Wallace, "from Sierra Leone to Celebes, and from Natal to Eastern Bengal and South China." How, it may be asked, can the apparently erratic nature of the distribution of these animals be accounted for? and how can the facts of such a straggling population be harmonised with those conceptions of orderly biological and physical laws on which the science of distribution bases its existence?

Mr. Sclater himself, in 1864, postulated the former existence of a continent occupying the site of the existing Indian Ocean. This continent, named *Lemuria*, he conceived might have formed the headquarters of the lemur group, whence they became radiated and dispersed east and west. Such an hypothesis is no longer required, however, to account for the curious distribution of the lemurs. In the light of new facts, and especially in the face of geological evidence, the existence of the theoretical "Lemuria" is rendered unnecessary. Mr. Sclater's perfectly justifiable supposition has simply been superseded by more natural explanations of the distribution of the lemurs, whilst the views entertained regarding the permanence of the great ocean basins and of the continental land areas are likewise opposed to the theory of a former land-connection between the Ethiopian and Oriental territories. For what are the geological facts concerning the range of the lemurs in the past? Their fossil remains occur in the Eocene rocks of France—that is, in the lowest and oldest of the Tertiary deposits—the remains in question being those of a form allied to the existing "potto" of West Africa; and in North America, where the lemurs exist to-day, the Lower Eocene rocks afford evidence of their existence in the past of the New World. So that we find at the outset our difficulties largely resolved by the bare mention of the idea that the existing anomalies in the range of the lemurs really depend upon their past history. In a word, as the "Marsupial" population of Australia is to be regarded as a survival, owing to land separation, of an animal class once world-wide in its range, so the lemurs now found at distant points in Africa and Asia, are merely the survivals of a lemurine family circle once represented both in the Old World and in the New. We know of their existence in Eocene times in Europe, and thence they probably spread in all directions—to Africa, Madagascar, Asia, and elsewhere. Killed off over the general area inhabited by their race, the lemurs have remained in the environs of the earth, so to speak, because there, to this day, the competition with higher forms is not too severe. Like the American opossums, the lemurs represent to-day the mere remnants of a once world-wide class. Their distribution has not

been one from Asia to Africa, or *vice versâ*, through a once existent "Lemuria," but has really been a diffusion from Europe, or from the Palæarctic region probably to the adjoining regions and to the New World.

A second case of difficulty in connection with the distribution of quadrupeds is that of the peculiar animals forming the order *Insectivora*, a group familiarly represented by the moles, shrews, and hedgehogs. This order of quadrupeds is highly singular in its range and distribution. It is entirely unrepresented in Australia and South America, and its representative species occur in the Palæarctic, Oriental, and Ethiopian regions; whilst North America also possesses moles and shrews, probably of very recent introduction into that continent. But more curious still is the fact that the Insectivora include certain peculiar and isolated animals, which inhabit detached regions, and which present problems for solution in the way of an explanation of the how and why of their existence on the earth's surface. For example, a curious animal (*Solenodon*) is found only in two West Indian islands, namely, in Cuba and Hayti. Again, the nearest relations of *Solenodon* occur in Madagascar, where, under the name of the *Centetidæ* or "Madagascar hedgehogs," they flourish in numbers. Thus we are required to explain the following facts: Firstly, the detached existence of *Solenodon* in the Antilles; secondly, the similarly isolated distribution of the species of *Centetes* in Madagascar; and thirdly, the absence of any species of *Centetes* in the intervening African continent.

In attempting to solve these problems we find that the way of investigation lies along the same lines as those which lead to a solution of the case of the lemurs. The existing Insectivora are small animals, mostly living in areas where they are removed from the direct effects of competition with other and stronger forms. Their fossil history is fragmentary but important; for we discover a link that connects *Solenodon* of the New World with *Centetes* of the Old World, in the fossil *Centetidæ* which occur in European deposits of Lower Miocene age. With even this solitary fact at hand, we begin to discover that the problem before us is not the bridging of the gulf between the West Indies and Madagascar, but the simpler task of accounting for the survival in out-of-the-way corners of the earth of a group once far more widely distributed. Thus Madagascar obtained its species of *Centetes* just as the West Indies obtained their *Solenodon*, namely, at a time when land-connection with a larger land area permitted these insectivores to gain admittance to what was shortly to become a detached island area. As has been pointed out, the conditions of life which exist in Madagascar closely resemble those of the Antilles, and both differ in turn from the conditions that prevail on the adjacent continents. There is an absence of large

quadrupeds, a lack of carnivores, a complete separation from larger areas by deep sea, and, in fact, a full representation of all the conditions which suit these insectivores, just as conversely on the continents the conditions are unfavourable to the prosperity and increase of their race. We do not require to connect the Antilles and Madagascar on account of these animals, any more than we need to postulate the existence of a former Pacific land-connection between Asia and America because the camels of the former continent are related to the llamas of the latter. And when we further reflect that Madagascar preserves a mouse nearly related to a New World type, and snakes belonging to a typical American group, we at once note how the principle of seeking to prove the former wide distribution of a race of animals and its modern limitation by geological and biological changes forms the best clue to many of the difficulties of this science. It is a clue, moreover, which is at once originated and supported by the fossil histories of the animals whose distribution is the subject of remark.

A third case which has excited the attention of students of distribution is that concerning the past history of the giant tortoises found in the Mascarene and Galapagos Islands—the former belonging to the Madagascar group, and the latter being situated 600 miles from the South American coast. Of these tortoises, as Dr. Günther has shown us, three chief groups exist. One of these inhabits the Galapagos, a second occurs on the coral island of Aldabra to the north of Madagascar, and a third, which has become extinct, inhabited the Mascarene group of islands. But our difficulties are lessened in this case—which demands the explanation of the existence of apparently similar forms in widely removed areas—by the knowledge that these tortoises, though apparently related, in reality belong to distinct types, and that, therefore, the necessity for presuming a connection between their distribution thus disappears. The Galapagos tortoises may be presumed to have come from the American continent; and as these animals can survive long exposure to sea, and are tenacious of life, their own conveyance or that of their eggs, on driftwood for example, is an hypothesis involving no great demands upon a scientific imagination. The Mascarene tortoises may have similarly been conveyed from Africa; and there is no greater difficulty, therefore, in accounting for the detached existence of these great reptiles, than in explaining how their more diminutive kith and kin, belonging, like the giant tortoises, to different groups, have acquired such an extensive range over the earth's surface.

Indeed, the case of the tortoises may serve to remind us of that of *Bassaris*, an animal formerly regarded as a kind of weasel or civet, but shown conclusively by Professor Flower to belong to the racoons of the New World. Bassaris, however, inhabits California, Texas,

and Upper Mexico, and when it was regarded as a "civet" (*Viverridæ*), an anomaly at once arose, since all known "civets" inhabit the Old World. But when the supposed "civet" was proved to be a member of the racoon group, all the difficulties of the case vanished; inasmuch as, being one of the *Procyonidæ* or racoons, it fell naturally into its habitat, since all the members of this family are limited in their distribution to the New World. An error in classification may thus generate anomalies in distribution which further research proves to have no real existence.

These illustrations of the manner in which the difficulties of distribution are resolved may serve to show besides the wide demands which this science makes upon well-nigh every department of natural science. The issues of distribution, in fact, involve an acquaintance with the entire range of not merely biological study but of geological investigation as well; whilst the deductions of distributional science, more perhaps than those of any other department of biology, open up before us the widest possible vista of human knowledge, and link together the varied interests of workers in every field of natural-science study. Nor is it in the grander aspects of this science that its far-reaching extent is alone to be seen. Even the apparently trivial details that constitute the story of the life existing on a barren and desolate islet may play an important part in the solution of questions dealing with the nature of life in its highest grades. Thus availing itself of knowledge from every source, this department of biology, more forcibly perhaps, as a whole, than any other branch of life-science, demonstrates how the true history of the existing universe is a history of variation and change—a chronicle, whereof the materials for each fresh chapter are derived from the lessons and the teachings of both the remote and the recent past.

VIII.

SONGS WITHOUT WORDS.

I AM spending a lazy holiday at the edge of a wood, and find life under a summer sky and in a summer temperature endurable, but nothing more. I recline on a mossy bank, and if not exactly *sub tegmine fagi*—for the tree overhead is a sturdy oak—I can yet appreciate the coolness of the shadow cast by the foliage above. A clear space in front, allows the eye to wander at will over meadow-land and corn-field. Some idle cows, animated by like impulses to those which impel humanity, are congregated beneath the beeches in an adjoining meadow, and sweep with their tails the humming congregation of flies bent on annoying bovine existence, which placidly ruminates, insects notwithstanding. The humming of the flies forms well-nigh the only sound one can hear on this stillest of days, but now and then a rook overhead will adjudicate some domestic difficulty with a loud "caw," and after a circling flight will once more sink to rest in the bosom of his family. Now and then a sleepy chirp reminds one of bird-existence above, but the laziness of living nature on a warm summer day is, to say the least of it, remarkable. In the thicket and apple-orchard beyond, I could find busy life in all its forms. I could show you my coleopterous friends the burying-beetles, hard at work interring the mouse that has come somehow or other to an untimely end; and to watch them toiling in their cuirassed jackets is a procedure exciting our sympathy much in the same way as you pity a fatigue-party of soldiers doing duty on a sweltering day. Bees, wasps, and flies, on their mission of pollen-distribution and flower-fertilisation, are busy enough in their turn; but the heat is cogent argument against work, and, like the cows, one may profitably rest and ruminate.

To-day one's thoughts glance off at a tangent, excited by no very poetical stimulus perhaps, but by an incident which, however commonplace it may seem, nevertheless leads to the domain of the natural, and, I will add, is somewhat within the vein of poesie also. My stimulus has been the cawing of rooks, the humming of flies and bees, and the chirping of a grasshopper—also lazily inclined, if I may judge from the quiet and self-possessed manner in which it progresses between the grass-blades close by. From the hearing of such sounds, one's thoughts insensibly merge towards the diffusion of voice in lower life at large. The faint tinkle of a piano reaches my ear through the

open window of the adjoining house. It is my hostess amusing herself with musical snatches, reveries, and reminiscences. Now it is a fragment of the last German waltz, musical, swinging, and so rhythmical that feet insensibly and automatically begin to describe imaginary circles, and the mind to conjure up visions of smooth waxed-floors, and gas-lights and whirling couples, keeping pace to the melody. Now, the waltz-phase has passed, and she strikes a sweeter chord. I should know these notes. Of course—the *Lieder ohne Wörte*, most poetical of strains, wherein one can find sympathy and consolation for many troubles of body and mind, and from which one can weave words and phrases to suit the impassioned chords and the fleeting moods of the listener's mind. Just so. Mendelssohn has inspired me with a title at least. I shall shake off the languor of laziness and hie me indoors ; and whilst my good hostess is pleasing herself and unconsciously delighting me with Felix the divine, I will indite me a little article on the "Songs without Words" one may hear in halls with leafy canopies, and in cathedrals whose aisles are flanked by massive columns of gnarled stems, and whose roofs are formed by the blue vault of heaven itself.

In which classes of animals do we find sound to be produced in lower life? Such is a query not inappropriate in view of the nature and extent of the fields over which our inquiries may travel. Our starting-point will be found in the insects, and possibly, also, amongst the nearly related but zoologically distinct spiders. Upwards we may travel through the molluscs, or shellfish, without meeting with any distinct example of sound-producing organs. Arriving at the lowest confines of man's own sub-kingdom, we pass to the fishes and find therein some few but notable examples of sound-producing animals. The frogs, with a not unmusical croak—a sound expressive enough in ears which are open to hear—come next in order ; and amongst the reptiles which succeed the frogs we find voice, it is true, but of indefinite type. Sweetest of all "songs without words" are those of the birds ; and it is both curious and important to remark on the structural nearness of the birds to the reptiles—these two classes being related in a most intimate fashion in many points of structure and development. Above the birds come the quadrupeds, with voices high and low, for the most part unmusical and often harsh, but possessing as their crowning glory the songs with words of man. Thus we discover a wide field before us, in the investigation of the voices which speak in the unknown tongues of lower life. Let us see if the interest of the subject may be found to equal its extent.

There is little need, I apprehend, to preface our discussion with a discourse on elementary zoology, by way of informing readers that only in the vertebrates or highest group of animals do we meet with

an approach to the vocal organs of man. Even in lower vertebrates themselves, as in many fishes, an organ of voice may be altogether wanting, and sounds, as we shall hereafter see, may be produced in fashions other than those in which man produces vocal sounds. What may have to be said of the voice of higher animals may be left for our after-consideration. We may begin our researches in a humbler vein, and investigate the "droning flight," the busy hum, and the lover's chirpings of insect life. We find a suitable text in the grasshoppers which chirp so loudly in the meadows around. A very curious order of insects is that which includes the grasshoppers, locusts, crickets, and earwigs as its chief representatives. They possess mouths adapted for biting, hinder wings which have straight ribs, and which are folded like fans, and, in the case of the first three insects, greatly elongated hind legs, conferring upon them a marvellous power of progressing by a series of leaps. As you hear the "cricket on the hearth" call to its mate, or the cricket of the field similarly attracting the notice of Mrs. Grasshopper, you might well be tempted to believe that the insects possessed organs of voice analogous to those of higher animals. But the song of the cricket is truly one without words, inasmuch as it is produced by a mechanical process of mere friction, and not through any more elaborate mechanism, such as one expects to find in the vocal apparatus of higher life. It is well to remark that in all cases the specialised sounds emitted by insects are intended as "calls" to attract the notice of their mates. It is a notable fact that the female insects, in the majority of instances, do not possess the means for causing sounds, and when present in the latter this apparatus remains as a rule in an undeveloped condition. Aristotle of old was perfectly familiar with this fact as applied to the classic cicada; and a not over-gallant poet, Xenarchus, hailing from Rhodes, inspired possibly by the memories of many remonstrances from the female side of the house, seizes the naturalist's text, and declares—

> Happy the cicadas' lives,
> Since all-voiceless are their wives.

An observation of Mr. Bates, in his "Naturalist on the Amazons," clearly shows the purpose served of the "stridulation"—as the faculty of producing sound is named in insects. A male field-cricket, like some gay troubadour, has been seen to take up his position at the entrance of his burrow in the twilight. Loud and clear sound his notes, until, on the approach of a partner, his song becomes more subdued, softer, and all-expressive in its nature, and as the captivated and charmed one approaches the singer she is duly caressed and stroked with his antennæ as if by way of commendation for her ready response to his love-notes. Thus insect courtship progresses much as in higher life, although, indeed, the siren-notes belong in the

present case to the sterner sex, and thus reverse the order of things in higher existence.

The sound-producing apparatus in these insects consists of a peculiar modification of the wings, wing-covers, and legs. Thus the grasshopper's song is due to the friction produced by the first joint of the hind leg (or thigh) against the wing-covers or first pair of wings —a kind of mechanism which has been aptly compared to a species of violin-playing. On the inner side of the thigh a row of very fine pointed teeth, numbering from eighty to ninety or more, is found. When the wing-covers or first wings are in turn inspected, their ribs or "nervures" are seen to be very sharp and of projecting nature, and these latter constitute the "strings," so to speak, of the violin. Both "fiddles" are not played upon simultaneously; the insect first uses one and then the other,—thus practising that physiological economy which is so frequently illustrated by the naturalist's studies. Some authorities, in addition, inform us that the base of the tail in these insects is hollowed so as to constitute a veritable sounding-board, adapted to increase the resonance of the song. And this latter faculty is still more plainly exemplified in certain exotic insects allied to the grasshoppers; these foreign relations having the bodies of the males distended with air for the purpose of increasing and intensifying the sound. Again, whilst, as already remarked, it is the gentlemen-insects which produce the sounds, there exist a few cases in which the lady-insects appear to emulate the violin-playing instincts of their mates.

The locusts are perhaps the most notable singers of their order. The locust's song has been heard distinctly at night at a mile's distance from the singers. In North America the katydid (*Cyrtophyllus concavus*), a well-known species of locust, is so named from the peculiar sound of the song, which closely resembles the words "katy-did-she-did," and a writer describes this insect as beginning its "noisy babble" early in the evening as it perches on the upper branches of a tree, "while rival notes issue from the neighbouring trees, and the groves resound with the call of *katy-did-she-did* the livelong night." In the locusts, the two front wings (or wing-covers, as they are called, from their function of protecting the hinder and serviceable wings) produce the song. The right wing is the fiddle, the left serving as the bow. A special rib on the under side of the latter is finely toothed, and is rubbed backwards and forwards over the upper ribs of the right wing, thus producing the chirp. When the crickets are examined, the disposition of the wing-covers is seen to resemble that of the locusts, but with the difference that both wing-covers have the same structure, each being alternately used as violin and bow. Of the grasshopper tribe, the locusts have perhaps attained to the highest pitch of musical efficiency; the grasshoppers themselves come next

in order, whilst the crickets are the least specialised and most primitive of all. It is a most noteworthy observation that in this group of insects a special organ of hearing is developed, the production of hearing powers thus taking place contemporaneously with the perfection of the song. Organs of hearing have been certainly discovered only in the insects under consideration. By some naturalists, the antennæ or feelers, borne on the head, have been credited with the performance of this function, but this view is problematical at the best. In the grasshoppers the "ears" consist of two organs, somewhat resembling drums in general conformation. These are found at the attachments of the last pair of legs. In the cricket and locust the hearing organs are found on the fore-legs. Thus it is both curious and interesting to find that the development of sounds and the production of ears to hear have taken place together in this group of insects, which geologically may claim to be one of the most ancient of the insect class. And the fact in question best illustrates to us that correlation between the varied ways and means of life which is so continually exemplified by the researches of workers in science byways.

We stray in pastures classical and especially Anacreon-wise, when we endeavour to investigate the biography of the cicada, whose marital happiness in the possession of a silent partner has already been remarked. Says Anacreon of the cicada :—

> Thee, all the muses hail a kindred being ;
> Thee, great Apollo owns a dear companion ;
> Oh ! it was he who gave that note of gladness,
> Wearisome never.

The Greeks of old delighted, and the Chinese to-day find pleasure, in the song of cicadas, imprisoned in cages like birds ; and as Kirby and Spence tell us, the emblem of music was a cicada sitting on a harp. This fashion of doing honour to the insect arose from the legend that Eunomus and Ariston, two rival Orpheuses, were contending for a prize in harp-playing. Eunomus broke a string of his harp during the competition, but a cicada, who, doubtless through a kindred interest in musical science, had been a spectator of the contest, flew to the instrument, and seating itself thereupon, supplied with its note the place of the missing string. Little can we wonder, of course, that Eunomus gained the prize in this legendary competition. The sound-producing apparatus of the cicada was formerly believed to consist of a special modification of the breathing openings of these insects. The breathing organs of insects consist of a complicated arrangement of *trachea* or delicate air-tubes which ramify throughout their bodies and convey air literally to every portion of their frames. The air is admitted to this peculiar system of air-tubes by means of apertures placed on the sides of the body and named

spiracles ; these openings being capable of closure at the will of the insect—a matter of absolute necessity for its safety during the rapidity of flight. The cicada sings during the day, and almost solely when the sun shines brightly. Virgil himself remarks of the insect that it sings, "sole sub ardente," and of the tropical species Mr. Bates remarks that "one large kind, perched high on the trees around our little haven, set up a most piercing chirp ; it began," continues our author, "with the usual harsh jarring note of its tribe, but this gradually and rapidly became shriller, until it ended in a long and loud note, resembling the steam whistle of a locomotive engine." Thus much by way of introduction to the cicada and its music.

Both sexes possess the musical apparatus, but that of the female is comparatively simple as compared with the "drum" of her mate, and is never used, as we have seen, for producing sounds. The apparatus in question is situated in the last joint of the cicada's chest and in the succeeding and front joints of its tail. Briefly described, the "drum" or "timbale" of the insect consists of a tightly stretched membrane and other structures, capable of being affected, stretched, and otherwise manipulated, by certain muscles, along with certain cavities destined to increase the resonance of the notes ; whilst we may not omit to mention the *spiracles* or breathing apertures as playing an important part in the production of the song. The drum is the song-producer, which, through its vibrations, gives origin to the characteristic sounds, and the accessory apparatus serves to increase the intensity of the notes. And the spiracles or breathing apparatus may be lastly noted to play an important part in this process, since they serve to maintain the necessary equilibrium between the external air and the atmosphere imprisoned in the cavities already mentioned, as serving to increase and intensify the sounds. Abundant evidence testifies to the fact of the song of the cicada being used to allure the female insects, and voice is thus again witnessed as a means of courtship. Is there, after all, not a strong analogy betwixt the love-song and the low and tender accents of the lover's part as played by humanity, and the song of the cicada with its varying intonations and accents appealing as powerfully in favour of the attractive swain as in the world of thought and mind? And it seems, indeed, a laudable enough inference, not merely that rivalry in song is a stated and regular occurrence in cicada-life, but that, through such competition in voice, the weakest go to the wall, whilst the most musical insects come to the front in the "struggle for existence."

An array of mailed forms, including "the shard-borne beetle with his drowsy hum," next demands attention. In no beetle, and indeed in no other insects, do we meet with the perfection of vocalisation seen in the grasshoppers and their relations. And with the beetle we

approach more clearly to the region of "hums" and droning, and leave that of specialised sounds, such as we have been metaphorically hearing in the cicadas. To pass from the latter insects to the beetles, bees, flies, and their neighbours, appears to be a transition almost as wide as that between the articulate language or arithmetic of culture, and the scanty vocabulary of the savage or the primitive mathematics of the tribe who can count ten as represented on their fingers and toes, but ask in amazement why there should be more things in the world. In the beetles the sound-producing organ is comparable to a kind of "rasp" which moves upon an adjoining surface. The site of the organ in question varies in different beetles. In some the rasps are situated on the upper surface of one or two of the tail-segments, and are rubbed against the hinder edges of the wing-covers. Sometimes the rasp is placed quite at the tip of the tail; and in some well-known beetles (such as the weevils) the rasps may be borne on the wing-covers and may produce the stridulating sound by rubbing against the edges of the joints of the tail. Amongst the sounds produced by beetles, the weird noise of the death-watch (*Anobium*) stands pre-eminent. The sound produced by these beetles resembles the ticking of a watch, and they may be made to respond by placing a watch close by their habitats. The female death-watches are known to tick in response to the sounds of the male insects. The noise is produced apparently by the insect raising itself on its legs and by its striking its chest against the adjoining wood. Thus the simple explanation of an insect call explains away the superstition expressed in Gay's line :—

The solemn death-watch clicked the hour she died.

Butterflies and moths are known occasionally to produce sounds, which proceed in one or two cases at least from a drum-like membrane analogous to that seen in cicada. Mr. Darwin, indeed, mentions that one species (*Ageronia feronia*) "makes a noise like that produced by a spring catch, which can be heard at the distance of several yards." Amongst the bees, wasps, and other so-called *Hymenopterous* insects, the production of the humming noise forms a fact of interest in the history of the race. And one or two species possess a power of emitting sounds of more definite nature, which correspond to the "stridulation" of the grasshoppers and their kind. But it is a well-known and at the same time interesting fact, that bees are known to express emotional variations by aid of their humming sound. "A tired bee," says Sir John Lubbock, "hums on E′, and therefore vibrates its wings only 330 times in a second." A bee humming on A′ will, on the other hand, increase its vibrations to 440 per second. "This difference," says Sir John, "is probably involuntary, but the change of tone is evidently under the command of the will, and thus offers another point of similarity to a true 'voice.' A bee in pursuit

of honey hums continually and contentedly on A′, but if it is excited or angry it produces a very different note. Thus, then," concludes this author, "the sounds of insects do not merely serve to bring the sexes together; they are not merely 'love-songs,' but also serve, like any true language, to express the feelings."

Every one must have noticed that the humming or buzzing of flies varies occasionally, and in accordance with the state of the insect; the sharp, high, excited "buzz" of the caught fly being markedly different from the placid hum of its ordinary existence. Landois maintains that a relatively low tone prevails during flight in flies; that the tone becomes higher when the wings are held to prevent their vibration; and that the highest tone of all is heard when all movement in the body of the insect is prevented. This last, he maintains, is that to which the term "voice," or, as we may put it, "song without words," may be applied. As such, it is produced by the *spiracles* or breathing apertures of the fly's chest, and it may be heard when every other part of the insect has been removed. The low note of ordinary life is caused by the rapid vibration of the wings in the air —the sound of F being produced by 352 vibrations of the wings per second; whilst when held captive a fly will move its wings 330 times in the same space of time. The second sound, or that produced when the fly is held captive by the wings, is caused, or at least is accompanied, by conspicuous movements of the joints of the tail, and by the frequent and rapid motion of the head against the front of the chest.

Such are the most prominent facts which entomology brings to view regarding the "voices" of insects. Spiders of certain species are known to be attracted by music, a fact which, if of valid nature, would appear to reverse the order of the tarantula's famed but legendary procedure. And it is an unquestionable fact that some male spiders possess the power of making a rasping noise by rubbing the hinder part of the chest against the front of the abdomen or tail.

From the insect-class and from the great army of the invertebrates at large, we pass to the confines of the sub-kingdom which claims man as its head; and in the course of an orderly survey of the field before us we arrive at the fishes as the lowest of the vertebrate group. To speak of "sound-producing" fishes appears to be an anomalous proceeding, inasmuch as the silence of fish existence is usually accepted as an article of unquestioning faith. But clear evidence exists that certain fishes do produce sounds of very definite character. Amongst those large-headed fishes the gurnards, two, named the "piper" and "cuckoo" species, are so named from the notes they emit on being taken from the water. These sounds are due to the muscular movements of the "swimming-bladder" of the fish, and are said to range over nearly an octave. Certain male fishes of the genus

Ophidium are known to produce sounds by means of a curious chain of bones connected to the air-bladder by muscles; and the maigres or umbrinas (*Sciæna aquila*), one of the best known of Mediterranean fishes, are, perhaps, more celebrated for their accomplishments in the way of producing a drumming noise than in any other respect. Some authorities have declared that the maigres produce flute-like notes, and the sounds are said to be audible in twenty fathoms of water. The male fishes alone make these noises, and Kingsley has recorded that the fishermen of Rochelle find it possible to take them without bait, by means of a skilful imitation of the noise. The drumfish (*Pogonias*) of North American coasts obtains its name from the loud and persistent noises it makes, and certain other fishes, belonging to different species, imitate the latter fish in this respect. "To this fish (*P. chromis*)," says Dr. Günther in his recent work on "Fishes," "more especially is given the name of 'drum,' from the extraordinary sounds which are produced by it and other allied Sciænoids. These sounds are better expressed by the word drumming than by any other, and are frequently noticed by persons in vessels lying at anchor on the coasts of the United States, where those fishes abound." "It is still a matter of uncertainty," adds Dr. Günther, "by what means the 'drum' produces the sound. Some naturalists believe that it is caused by the clapping together of the pharyngeal teeth, which are very large molar teeth. However, if it be true that the sounds are accompanied by a tremulous motion of the vessel, it seems more probable that they are produced by the fishes beating their tails against the bottom of the vessel in order to get rid of the parasites with which that part of their body is infested." Dr. Günther's explanation of the production of the noise of the Pogonias necessarily destroys any connection between that sound and the mating instincts of these fishes. But in other cases, from the almost universal absence of the sound-producing power in the female fishes, we are forced to conclude that the faculty in question is used and designed as a means of attracting the latter to their mates.

Perched on a comfortable log of wood is a frog, surveying nature with the placid stare of contentment which as a rule amphibians preserve under the most trying circumstances of life. I know that Mr. Rana Temporaria (as he is designated in scientific circles) possesses a voice, but that he elects to let himself be heard, as a rule, only when it suits himself. You may get round your frog, however, by an ingenious physiological trick, much resembling the act of an unknown benefactor who knows you are bound to laugh when he tickles you under the arms. Did you ever hear of Goltz's experiment of the "Quak-versuch"? No: then suppose that Mr. R. Temporaria Clammyskin, as he sits before you, could be deprived of the front lobes of his brain. The mechanism of the experiment is simple in the

extreme. Draw your finger gently down the middle of his back, and when you touch a given part of Clammyskin's surface, the frog, *minus* the front lobes, will croak. He will not croak unless you stroke his back: but regularly, as if you touched the "croaking-stop" in the amphibian organ, he will emit his single note, whenever your finger arrives at the stated spot. There is much that is obscure here, but the *rationale* of the inscrutable croak is at least clear. It is produced by an order of the part of the brain which governs the vocal organs of Clammyskin, and which part is stimulated unerringly and unvaryingly by the outward stimulus supplied by the touch of the finger. But when possessing his front lobes, the frog may still be made to croak by the application of gentle stimulus to his back, whilst naturally the male frogs are given to croak incessantly at the time of egg-deposition. The male voice asserts itself in a very marked manner over that of the female frogs, and in the scientific version of

A frog he would a-wooing go,

the croak counts for much, both as a sign of attractiveness in the wooer, and of his progress in his suit. When we have attained to such heights in the science of mind as may entitle the scientist of the future to write the "Comparative Psychology of the Frog's Wooing," and of the Clammyskin tribe in general, the language of the croak may prove to be more diverse and eloquent than we may now suppose to be possible. There can be no doubt, even in the present state of our knowledge, of the overwhelmingly powerful nature of the oratory prevalent in our ponds and ditches in the months of early spring.

Vocalisation of the highest types now awaits a brief review; and perchance, by way of introduction, you may not object to be reminded of the nature of the vocal organs and of that curious machinery wherewith the mind finds outward expression in so many and varied ways. Every one knows that voice comes from a region situated somewhere near "Adam's apple." To be sure, this is no very definite way of expressing the anatomy of the organ of voice, but it serves the purpose of localising the faculty, at any rate. The human "larynx" or voice-organ, to be brief, exists at the top of the windpipe, as a kind of gristly box, composed of elastic and movable cartilages of which "Adam's apple" is both a prominent and important example. This gristly box is placed in the direct track of the air-currents passing to and from the lungs. Its entrance is guarded above by a little lid (the *epiglottis*) which prevents food-particles from "going the wrong way." Inside the box are two folds of mucous membrane, named the *true vocal cords*; other two folds (the *false vocal cords*) also exist, but the latter do not aid in the production of voice. By the varying alterations and degrees of tension

produced upon these cords by means of special muscles, and primarily through the outward passage of air-currents from the lungs, voice and its variations are produced.

Such is an outline of a lesson in elementary physiology which may be more fully learned, to the advantage of all herein concerned, from a shilling primer such as we may see—thanks to the advance of true culture—in use in very many of our secondary schools. The vocal organs of birds are constructed on a type essentially similar to that of man; but were we to apply to a primer of zoology for further information concerning the bird-class and its voice-organs, we should be told that birds actually possess two such organs—one situated as man's is placed, at the top of the windpipe, and one at the root of the windpipe, just before that tube divides into two to supply the lungs with air. Thus birds have an upper larynx and a lower larynx; and it is the latter which is the true organ of voice. Of all points in the history of birds, none is more surprising than the extreme variations in their song. A warbler has just finished its trill, with a burst of sweet melody that makes me long for a repetition of the song; the memory of the skylark's chaunt is ever-present with us as a morning hymn; and the night closes with a varied concert from the wooded grove in front of the house. The notes of the ducks bring before us another phase of bird-voice, the sharp pæan cry of the peacock resounds in our ears, and the clang of the swan reminds us of the harsh and discordant as well as the sweeter lays of bird-life. "Why do birds sing?" asked the naturalists of old, and each supplied a different answer to the query. Says Montagu, the "business" of the male song birds "is to perch on some conspicuous spot, breathing out their full and amorous notes, which by instinct the female knows, and repairs to the spot to choose her mate." Once more the love-song theory appears to view, and finds its support in facts. Bechstein, careful observer and enthusiastic ornithologist, tells us that finches and canaries will choose the best singer as a mate; and the lady-nightingales are known to place the same high estimate on a fine flow of song. Then comes the "rivalry and emulation" theory, founded, to my way of thinking, upon the too lax notion that birds are bound to imitate the feelings of humanity, and which declares that birds sing for the sake of vanquishing their fellows, and that in every wood an "Eisteddfod" is held, with its exhibition of vainglory, jealousy, and emulation in the musical art. But emulation, if it exist, may be a part of the ordinary business of courtship, as one has every reason to believe it forms no small part of the phenomena of love-making in higher life, and the theory of rivalry in song may thus be included in the larger theory that birds sing because they mate, and mate because they sing.

Another important consideration remains to be noticed. It is

a curious fact that the bird-songsters are all of the smallest size. Rarely, if ever, do we hear a melodious voice in a large bird ; the Australian *Menuras*, or lyre-birds—so named from the shape of the tail-feathers—birds which may attain the size of a small turkey—being the most notable exception to the general rule above-mentioned. Then, too, we shall find that the songs of birds may and do improve by culture. Sparrows will learn in time to sing most melodiously ; and of course there is no end to the list of tunes or sounds a mocking-bird may acquire. In addition to true song, some birds may, as Darwin has it, practise "instrumental music." The turkeys "make a joyful noise" in their own fashion by scraping their wings on the ground, and the snipes, and grouse, "drum" with their wings, as also do the male goatsuckers or "nightjars."

Our study draws to a close. I promised at the outset that it could be nothing better than sketchy in its nature, and it has been an easy matter to fulfil a promise of the kind in question. But outlines are preliminaries to complete pictures ; and if I have neither the courage nor the temerity to fill in the sketch, I am well content to have perchance paved the way for a fuller consideration of the questions regarding the origin of songs with words and songs without words which contribute so much to our rational and natural enjoyment, and I will add instruction in the ways of living things likewise.

The evening begins to draw nigh ; and already the singers of the day are leaving their leafy orchestra, and flitting homewards to rest. That weird mammal the bat—vestige, as it seems to me, of the great flying Pterodactyls of the middle ages (of geology)—is abroad, looking after his interests in the way of gnats, moths, beetles, and such belated flies as may have innately determined that they "won't go home till morning," like certain rustic friends in the neighbourhood, who thus declare on leaving "The Swan with Two Necks" in the village—but of whom a chief peculiarity is that once home they won't leave home for work when the morning comes, a fact explicable possibly on grounds connected with obscurity of the cerebral circulation. The bat sweeps round and round, but is no singer of mine, although it squeaks when caught. Possibly under training the bat, like the mouse, might "sing"—and I heard a mouse sing sweetly behind a wainscot once upon a time.

I hear a faint stirrage amongst the crows in the nests overhead ; Mr. Crow possibly absorbing too much house-room, and Mother Crow expostulating on behalf of herself and progeny. The beetles are out for the evening, and now and then a late dragon-fly wheels and sweeps along, regardless of certain active birds with wide gapes that hover near like aërial spectres. I hear a frog croak now and then—by way of assurance, I presume, that the Clammyskin family "never nods," but is invariably active and alive to the exigencies

of life. The twilight deepens. There are sounds of stirring in the adjoining room. I hear my hostess play a prelude to a favourite ballad. She plays charmingly, and sings well; this last the highest expression of vocal development, and one which served doubtless in days gone by to captivate the heart of my friend the host, as in reverse order the cricket's chirp enchants Miss Acheta, or as the sweet song of Mr. Nightingale tells of his love for the listening beauty. Very good. I shall wipe my pen. Now for "songs with words." Good-night.

IX.

THE LAWS OF SPEECH.

AMONGST the many and diverse problems which the modern tendencies of science have evolved, few possess for us a deeper interest than those which deal with the origin and beginnings of language. It is little to be wondered at that in early days the power of "wedding thought to speech," to parody the Laureate's well-known expression, should be regarded as, of all gifts, that for which man was directly indebted to the goodness of the gods. Nor is it a subject for surprise to find the legendary punishment for presumptive enterprise at Babel taking the form of a confusion of tongues—thus rendering impossible the further prosecution of that famous erection. Of late years, the problem concerning the beginnings of speech has acquired a special importance from its obvious relationship to other questions intimately connected with the early conditions of mankind. There exists hardly a single phase of the evolution hypothesis, as applied to the explanation of humanity's ways and life, which does not in some fashion or other touch upon the origin of speech and the beginnings of that faculty whereby man has learned to express the ideas of his mind—or, contrariwise, as some philosophers would insist, to conceal his thoughts. To the moral philosopher, the power of speech is the central pivot on which man's personality hangs. His opinion of speech as related to thought is usually that of Plutarch, who, in the "Life of Themistocles," tells us that "speech is like cloth of Arras, opened and put abroad, whereby the imagery doth appear in figure; whereas in thoughts they lie but as in packs." It is not our intention in the present paper to discuss those larger issues which arise from the consideration of the later developments of speech as related to the progress of human kind. Our special field of study lies rather in the direction of the first beginnings of language, and in its early growth and origin as viewed from the biological standpoint. We need concern ourselves, therefore, with little speculation of purely metaphysical kind, taking our stand primarily within the domain of life-science, where, indeed, all legitimate research into man's early history may be said to begin.

Through language, then, man maintains his personality, and provides for the extension of his own influence, whilst thuswise he also reciprocates the influence of others. This power of communicating with his fellows constitutes the basis of the language-faculty,

which, broadly regarded, is not necessarily associated with speech. The savage in his contact with the civilised man, or one civilised man in his relations with his equals, may employ the language of gesture, and be perfectly understood, as one may daily prove by crossing the English Channel and watching our unsophisticated neighbours in their converse with the foreigner. In lower life, there is abundant evidence that communication of a very distinct kind by means of signs or acts is a common practice. Some species of ants, for instance, keep the aphides, or plant-lice, of our gardens in their nests much as we keep cows in dairies, or seek the plant-lice in their native haunts on the bushes and flowers, where, to the gardener's disgust, they exist by the score. Approaching its aphis-cow, the ant proceeds to milk it by stroking the tail of the insect with its antennæ or feelers. Thereupon the "cow" emits a drop of a sweet secretion which the ant greedily drinks, and then hurries off in search of a fresh subject. There has evidently been induced and perfected in this case a close relationship between ants and aphides; since we note that the latter are protected in many ways by the ants, and exhibit a perfect docility of demeanour under the treatment to which they are subjected by these impersonations of insect wisdom.

One species of ant (*Lasius flavus*), indeed, is known to live chiefly upon the honey of the plant-lice which feed upon the roots of grasses. In this instance, the plant-lice are kept in the ants' nest, their very eggs being tended by the ants with an evident desire of securing future favours; "an act," says Sir John Lubbock, "which one is much tempted to refer to forethought, and which in such a case implies a degree of prudence superior to that of some savages." But that the mere touch of the ants' antennæ possesses all the significance of a sign-language is evident from the spontaneous response which the plant-lice make to the stimulus, and likewise from the impossibility of imitating the ant's procedure. Mr. Darwin tells us that on one occasion he "removed all the ants from a group of about a dozen aphides on a dock-plant, and prevented their attendance during several hours. After this interval I felt sure," continues Mr. Darwin, "that the aphides would want to excrete. I watched them for some time through a lens, but not one excreted; I then tickled and stroked them with a hair in the same manner, as well as I could, as the ants do with their antennæ; but not one excreted. Afterwards I allowed an ant to visit them, and it immediately seemed by its eager way of running about to be well aware what a rich flock it had discovered; it then began to play with its antennæ on the abdomen first of one aphis and then of another; and each, as soon as it felt the antennæ, immediately lifted up its abdomen and excreted a limpid drop of sweet juice, which was eagerly devoured by the ant. Even the quite young aphides," adds Mr. Darwin,

"behaved in this manner, showing that the action was instinctive, and not the result of experience." Here there has been developed a series of responsive acts indicating a degree of relationship of a highly intimate character, and illustrating the fact that communication by touch in lower life may be of very perfect kind. The consideration of the utilitarian and instinctive nature of the act in no sense invalidates the inference that a language of touch exists and perfectly fulfils the requirements of the lower life which has developed it.

The problem of the communication of lower animals by signs or touch is of course of difficult nature, and in many of its phases impossible of solution. But that means for communicating intelligence do exist, is an unquestionable fact. No doubt exists that ants recognise their neighbours belonging to the same nest; yet, considering that in some nests the number of inhabitants may amount to one hundred thousand, it seems well-nigh hopeless to undertake the explanation of their means of communication, or their grounds of recognition. Nor are these grounds rendered clearer by the facts related by Sir John Lubbock concerning the recognition of friends and strangers, even in the young state. "If the recognition," says this author, "were effected by means of some signal or password, then, as it can hardly be supposed that the larvæ or pupæ would be sufficiently intelligent to appreciate, still less to remember it, the pupæ which were entrusted to ants from another nest would have the password, if any, of that nest, and not of the one from which they had been taken. Hence, if the recognition were effected by some password, or sign with the antennæ, they would be amicably received in the nest from which their nurses had been taken, but not in their own"—unless, indeed, the knowledge of their own password be regarded as a matter of inherited instinct like the chief acts and details of ant, wasp, or bee life. A number of pupæ were taken by Sir John Lubbock from nests tenanted by two different species, and placed in small glasses, "some with ants from their own nest, some with ants from another nest of the same species." The result was, that thirty-two ants of the two species taken from their nests in the pupa (or chrysalis) state, "attended by friends, and restored to their own nest, were all amicably received." In another case of twenty-two ants which, as pupæ, had been brought up by strangers and afterwards returned to their own nest, "twenty were amicably received, though in several cases after some hesitation." The result of such experiments seems to show that ants of the same family circle do not recognise each other by any password; whilst, in some cases, ants brought up by strangers, and then restored to their friends, may be received by some of their relatives with hesitation. It is, however, equally notable, that strangers placed in a nest

under such circumstances would be unhesitatingly and invariably attacked.

That ants undoubtedly possess a substitute for the language of higher life, appears to be well-nigh certain. Possessing a power of recognition, they exercise such a power in some fashion unknown to us; and they are able to communicate important and necessary intelligence, say of the proximity of food, to their neighbours. Such intelligence may be merely the result of the exercise of scent or smell, as in some cases Sir John Lubbock's experiments seem clearly to prove. But, in other instances, it is as clearly proved that these insects transmit ideas. This latter fact was shown by an experiment in which ants having access to many larvæ brought 257 friends to assist in conveying their infants home; whilst those which were placed to few larvæ only brought eighty-two coadjutors. The inarticulate language of the ant is, however, paralleled by the audible language of many of its insect brethren, in a form of communication which may to all intents and purposes be named "the language of love," since most of the distinctive sounds emitted by insects are intended as "calls" from the male to the female, and as a means of determining the locality of the callers. That the language of insects, then, is an inarticulate form of speech no one may deny. Its purport, however, is not only clearly understood, but the development of specialised powers of hearing has occurred *pari passu* with that of the plainest form of this insect-voice.

Passing now to higher animals, we find that the beginnings of a system of communication with their fellows, more nearly approaching that exercised by man, occurs in those animals which most nearly approach the human type of structure. The forms of vocalisation which are to be noted amongst our familiar animals are many and varied, and are plainly recognisable as indicating different phases of feeling. The angry neigh or scream of a horse in pain, or under the influence of terror, is very different from the ordinary cry of the animal; and the howl of a suffering dog is as eloquent in its demonstration of pain as are the interjections of his master. But the range of voice and expression in certain animals—a subject to which our attention has not been sufficiently drawn—is not by any means of limited nature. One monkey, the *Cebus azaræ*, is known to utter at least six different sounds, expressive of as many distinct states of feeling and of as many varied emotions; and this animal is by no means singular in his modulation of voice to express the moods and tenses of his life. The dog, according to Darwin, has learned to bark in four or five different tones, and has thus unquestionably evinced a decided advance upon his wild progenitors. There can be no doubt that in early human existence a striking likeness to the habitual modes of expression of lower animals exists. The infantile "crow"

of pleasure is analogous to the bark of the pleased canine, or the "purr" of his feline neighbour; just as the cry of the young child is paralleled by the pained yelp of the dog. And if we only consider it, there exists perhaps a still closer resemblance betwixt the inarticulate, spasmodic, and long-continued "cry" of the infant, and the long-drawn-out howling in which a young puppy indulges, as compared with the shorter and less demonstrative cry of the dog. Between the early life of the man and the infancy of his faithful follower, there is a closer likeness in respect of the expression of the emotions than between the human infantile demonstrations and those of the adult dog. This much every one admits, of course. The difficulties of the question, however, really commence with the attainment of the power of "articulation"—the joining of simple sounds to form words, which in their turn are the outcome, firstly of "ideas," and secondly of special powers of brain and nerve action. Archbishop Whately long ago owned that man "is not the only animal that can make use of language to express what is passing in his mind, and can understand, more or less, what is so expressed by another." Here it is clear the idea of "language" intended to be conveyed is simply that of the audible expression of emotions or idea, and, thus defined, an intelligent dog may be said to possess a language of his own, equally with man himself.

"Articulate speech" is, however, the highest form of this common faculty we name language, and it is the origin and development of the power of forming words, and of stringing words together to express ideas, which form the chief problem awaiting solution at the hands of the theorists and investigators of the present and future. The philologist, pure and simple, will naturally approach the subject from his own special side by a comparison of existing and extinct tongues, and by the endeavour to show their points of resemblance, and to detect the causes on which their differences depend. The mental basis of language does not form a controversial ground, save, indeed, in so far as one authority may be held to differ from another respecting the exact amount or kind of mental power which is requisite to evolve ideas. On such a subject, as connected with the differences or likenesses between the human and lower intelligences, there may be considerable difference of opinion, it is true. But all are agreed that language has arisen out of the demand for expression, and the real battle-field lies within the territory where the origin of such demand is discussed.

The "understanding ear" is not of course the exclusive property of mankind, otherwise an intelligent collie must be presumed to receive and obey the complex order of his master by some other channel than that of hearing and consequent appreciation of his master's commands—a supposition so absurd that no further mention need

be made of the fact that many lower animals hear and understand what is said to them. Here, again, the analogy between the infant's appreciation of what is said to it, in the absence of any power of speech, and the understanding of the speechless dog, is too close to escape even casual notice. As respects the mere power of articulation, an intelligent parrot, magpie, or starling will speak with a clearness which often deceives humanity into the belief that a "brother man" is addressing it. To say that such a power is merely that of accurate imitation, neither explains the acquirement of this faculty by the bird, nor elucidates what is an undeniable fact, namely, that a well-trained parrot will frequently ask questions, give replies, or make remarks in a fashion as appropriate as if its words were dictated by a human understanding. Numerous verified accounts of such faculties are to be found in the records of natural history. The writer remembers seeing an old gentleman much perturbed, whilst in the act of wiping a bald head with a banana handkerchief, by hearing a gruff voice exclaim, "My! what a head!" The remark proceeded from a parrot sitting on a perch close by. The owner of the bird being duly interrogated, declared that the expression was one by no means frequently used by the bird, but which had of course been suggested by the sight of the hairless cranium. This bird was also accustomed to discriminate in a highly remarkable fashion between its other remarks, producing, as a rule, from its *répertoire*, which was of a highly extensive nature, suitable answers for each occasion. Mr. Darwin tells us that a parrot, of which he had a verified account, was accustomed to call certain members of its household and visitors by their names, and to say "Good morning" and "Good night" at the proper times without confusing the occasion and the expression. After the death of his owner, a short sentence invariably spoken after the salutation "Good morning" was never once repeated. Of a starling, nearly the same remarks hold good, this bird saying "Good morning" and saluting its visitors on leaving with unvarying correctness. In the case of these birds, there must exist the power of associating sounds with ideas, a power which in its highest development may be said to confer upon man all the peculiarities and special features of the human mastery of speech. If, as has been remarked, "the language which expresses discrimination and judgment is a testimony for mind," a parrot judged by this standard cannot be regarded as destitute of mental powers. As "an index of mental procedure," the language of the parrot is indicative of a stage in the use of that procedure far behind the development of the average human intellect, it is true, but comparable, in certain of its phases, with the low developments of association, discrimination, and speech met with in the most primitive races of men.

As we have already remarked, with the mental processes, intricate or otherwise, involved in the exercise of language we have nothing at present to do. Admitting that, as is highly probable, the exercise of speech implies and means the possession of an intricate power of muscular co-ordination, with the transformation of ideas into words—itself an intricate and inexplicable process—we may more profitably inquire if general biology, aided by physiology and incidentally by philology, can direct us toward the probable beginnings of the language-faculty in man. We have seen that emotional states in lower life become visible and audible through corresponding sounds and expressions. Professor Whitney remarks that man possesses a natural desire to communicate with his fellows, and that in such a desire is to be found the chief condition which, in the development of language, "works both unconsciously and consciously; consciously as regards the immediate end to be attained; unconsciously as regards the further consequences of the act." Max Müller, in his "Lectures on Mr. Darwin's Philosophy of Language," lays down the axiom that "there is no thought without words, as little as there are words without thoughts"; but the great philologist must surely in such a case be using the term "words" as implying the mental images or concepts which stand as the unexpressed result of thinking, and which the act of speech enables us to convey to the hearers. Otherwise the aphorism hinges on a very special and peculiar idea of the term "thoughts," the nature and discussion of which term fortunately lies beyond our present aim. Whitney, remarking Bleak's views respecting the impossibility of the existence of thought without speech, says:—"Because on the grand scale language is the necessary auxiliary of thought, indispensable to the development of the power of thinking, to the distinctness and variety and complexity of cognitions, to the full mastery of consciousness; therefore he would fain make thought absolutely impossible without speech, identifying the faculty with its (human) instrument. He might just as reasonably assert that the human hand cannot act without a tool. With such a doctrine to start from," adds Professor Whitney, "he cannot stop short of Müller's worst paradoxes, that an infant (*in fans*, not speaking) is not a human being, and that deaf mutes do not become possessed by reason until they learn to twist their fingers into imitations of spoken words." The truth of the idea that, without words to think, thought becomes impossible, has been a little overstrained. We do not deny the power of thought to a dog, but we admit he does not possess language—in which case we are simply arguing concerning a true idea of language, which, the broader it is made, will serve our purpose the better. It is not, however, a rational idea that the necessity for the formation of word-concepts of his thoughts forms the real foundation of speech. Would the thinking

powers of a human being living a solitary existence, of themselves develop a language? There are of course but few facts to which we may appeal on this head, but such facts as we do possess militate powerfully against such a belief. Solitary man would be a speechless creature; and hence, may we not logically assign to social tendencies and a gregarious nature a large share and a most undoubted influence in the production of language?

But by what theory can we urge that the language of man has become developed from the acts, or roughly expressed emotions, of lower existence; seeing that, on any theory of development, we require reasonably to believe that such a faculty as language, paralleled by the "expressions" of lower life, must have originated in the higher development of the latter? Two theories find favour in the eyes of philologists, being known respectively as the "ding-dong" and the "bow-wow" hypotheses. Briefly stated, the "ding-dong" theory founds its explanation of the origin of speech on the idea that the conscious nature and mind of man responded to external impressions very much as a bell responds when struck, and that in this way the roots of language were formed in the shape of a number of "sound-types." But the mental constitution of man is not analogous to the bell. Each conception of mind would not necessarily give origin to one stable and fixed sign or symbol of its presence and nature. More reasonable by far is it to suppose that the choice of a sound to represent an idea originated in some mental act responding to the object suggesting the idea—much in the same manner as an infant, on hearing a dog bark or a cow low, should thereafter indicate the one by saying "bow-wow," and the other by the primitive "moo." Nor must we lose sight of a distinction which has not been insisted upon sufficiently, and in many cases overlooked entirely, in discussions on this subject—namely, that the simple sounds of which a primitive language must have consisted, would be derived primarily from the comparatively few objects by which early man was surrounded. The more complex combinations of sounds found in the language of after ages would naturally be a later development, when primitive man's concepts and thoughts increased in number and diversity of range, and when he possessed a wider sphere of action, and lived in the presence of multifarious and amid varied surroundings.

Sounds, then, were derived from the actions or objects they were intended to indicate. Such is the "bow-wow" theory of the origin of language, otherwise named the "mimetic" or "imitative" —or, if we prefer the learned equivalent, the "onomatopoetic"— hypothesis. Mr. Darwin states the general ground of the "bow-wow" theory in plain terms when he says:—"I cannot doubt that language owes its origin to the imitation and modification of various natural sounds, the voices of other animals and man's own

instinctive cries, aided by signs and gestures." If one were disposed to be critical in respect of this plain statement of the origin of speech, such criticism might lie in the direction of assigning a higher place to the "signs and gestures" of primitive man than Mr. Darwin gives them. The movements of expression, as representing the most patent results of certain thoughts, would contribute, I hold, quite as much towards the association and stereotyping of certain sounds to form language, as the cries or sounds which in themselves might be held to represent the beginnings of speech. Indeed, if priority is to be assigned to any of the contributing elements of language, the gesture or sign may reasonably enough be regarded as the antecedent of the sound. One objection to the "bow-wow" theory has been founded on the observation that, were its main features true, and if the earliest words were merely imitations of natural sounds, we should find similar primitive concepts to represent the same objects under all circumstances. But do we not frequently find such likeness? Witness the word *crow*, its Latin *corvus*, Greek *kŏronē*, Sanskrit *kâraṿa*, and its root *ru* or *kru*, to call; or the example cited against the "bow-wow" theory by Max Müller himself, namely, *moo*, the nursery name for cow, Indian *gu*, Teutonic *kuh*, and Greek-Latin *bou*. Is not "cuckoo" the exact representation of the bird's voice? Is not the "mu-mu" of the West African negro, meaning "dumb," the most natural reproduction, like our own "mum," of a significant term for silence, as "rap" and "tap" are obvious imitations of common sounds? Apart from the fact that such likeness as is demanded by the "bow-wow" theory of language does exist, there still remains a very obvious explanation of the dissimilarity which exists between many primitive sounds and root-types of words. The early efforts of the primitive mind did not seek a uniformity or aim at an exact sameness of sound in constructing a representative word. There existed at the most an attempt at a plausible imitation. As the primitive sounds themselves were varied, so the mental powers which received and imitated them were of diverse calibre. In the beginnings of mental activity, there must have existed shades and variations of receptivity, just as, in their later development, mental phenomena vary with the individual and the race. So that the differences existing between the primitive word-concepts may be traced to natural variations in the mental skill or powers which reproduce them, or to the process of phonetic decay. And thus also existent likeness between word-concepts are only explicable in a natural fashion, on the principle that primitive man imitated, as best he could, the first sounds which presented themselves to his opening ears and dawning intelligence.

This slight incursion into the domain of the philologist may be excused on the ground that it furnishes us with the main points of

the argument which it is the object of physiological evidence to substantiate and support. The subject of speech in its physiological relations has been needlessly complicated in certain quarters by a tendency to overlook the very plain but important evidence which the study of such conditions as idiocy and deaf-mutism in man affords respecting the origin of language; whilst the observation of lower life and its peculiarities may serve to aid us, as before, in the further understanding of the evolution of words. Instinctively we recognise the cry of pain or fear, in lower life, as distinguished from the audible expression of joy; and in human existence there are analogous means for conveying to others precisely the same information of our mental states and conditions. There can be little difficulty in satisfying ourselves that an imitative tendency unconsciously exercised, as man's intelligence awoke to its new and higher duties, would amply suffice to develop and perfect the acquirement of words and the enlargement of ideas.

Nor is such an involuntary tendency of the mind to excite intuitions and ideas unrepresented in ourselves, or in other mental acts than those concerned in the production of words. "Each word," says Dr. Maudsley, "represents a certain association and succession of muscular acts, and is in itself nothing more than a conventional sign or symbol to mark the particular muscular expression of a particular idea. The word has not independent vitality; it differs in different languages; and those who are deprived of the power of articulate speech must make use of other muscular acts to express their ideas, speaking, as it were, in a dumb discourse. There is no reason on earth, indeed, why a person might not learn to express every thought which he can utter, in speech, by movements of his fingers, limbs, and body—by the silent language of gesture." Such remarks have a special and authoritative bearing on the opinion expressed in a former part of this paper concerning the importance of primary gestures and signs over sounds, as factors in the production of language. The movements of speech, then, do not differ in kind from those exhibited as the result of other bodily actions; their connection with the mind is simply more intimate than that which is implied, say, in the act of raising the hand to the mouth. The connexus which has been established between brain and larynx is simply of a more delicate nature, simply responds more accurately—because, perhaps, more frequently—to the calls made upon it in the production of words than the relation existing between brain and finger. There is the closest of parallelisms to be drawn in respect of the action and reaction of mind upon visible speech, between the production of words and the reception of sensations of light by the eye or of sounds by the ear. Delicate impulses transmitted to the brain

result in images of things seen, or in sensations of things heard; and as brain-force or mind appreciates in this case, so does the same force, when stimulated in another direction, become transformed into the audible ideas whereby we know ourselves, and become known of others. "We should be quite as much warranted," says Dr. Maudsley, "in assigning to the mind a special faculty of writing, of walking, or of gesticulating, as in speaking of a special faculty of speech in it."

Mr. Darwin has been careful to point out that the relation existing between "the continued use of language and the development of the brain" has formed an important factor in strengthening and perfecting the power of speech. An increase of brain-power would act favourably upon the use of words and ideas, and the practice of speech, at first rude and imperfect, would react upon the brain in turn. Trains of thought in ordinary life may be unaccompanied by any outward manifestations or by words, it is true; but the person who, during a reverie, suddenly breaks out into speech, illustrates in a very apt fashion the idea that the earliest attempts to frame word-concepts of things must have originated in outspoken sounds accompanying the muscular actions and the vivid ideas which were just struggling into existence. But the history of deaf mutes affords much valuable evidence and many important hints regarding the primitive condition of the language of mankind. Persons born deaf are, as is well known, also dumb. A want of hearing prevents the formation of concepts or impressions of distinct vocal sounds. The case of neglected deaf mutes illustrates this fact; for those unfortunates are as completely isolated from their fellow human beings as are lower animals from man, and their minds, in respect of the primitive nature of their ideas, may be held to represent the original mental states of early mankind. When, on the other hand, such persons are trained to speak, they evince in the course of their education a series of advances which unquestionably bear some analogy to the progress of man in the art of speech. What may be said to be the condition of the mind in the deaf mute, isolated by his infirmities from his fellows in the most complete manner, and debarred from participating in those social or gregarious tendencies which, as we have remarked, count for so much in the theoretical understanding of the beginnings of language? These persons, in thinking, use no abstract conceptions save of the very simplest order. To use Mr. G. J. Romanes's description of the experiences of an educated deaf mute, such persons think in pictures—so concrete are their notions of the outer world. Abstract ideas, such as those of God and heaven, are entirely absent. Religion, in the absence of language, is also non-existent. One deaf mute told his teacher that prior to his education he supposed the Bible to have been printed in

the sky by printers of great strength: one interpretation of attempts to teach the deaf mute, by gestures, that the Bible was believed to be a revelation from God. Another deaf mute supposed that the primary object of going to church was to honour the clergy—a primitive conception which, by the way, seems by no means an unnatural thought in days when mediævalism and extreme devotion to clericalism reign rampant around us. If the deaf mute, with every claim to the possession of a truly human brain and body, appears to be well-nigh in the condition of the dog in the absence of abstract ideas, it is not difficult to frame the important generalisation that to speech the typical man owes most if not all of those qualities and traits which so sharply demarcate him from lower forms of life, to which he nevertheless nearly approaches through the deaf mute, the idiot, and the lowest savage. It is the presence of this descending ratio that gives countenance to the details and ideas with which we have been hitherto dealing, and in which the origin of man and man's language from lower states of existence and from lower concepts of things has been contended for.

The case of Laura Bridgman, born in 1829, reported by more than one authority on mental diseases, presents us with an instructive illustration of the growth of the power of sign-language, and of the evolution of ideas to correspond therewith. When two years old this girl became blind and deaf from the effects of scarlet fever, her sense of smell and of taste being blunted. At seven years of age she was described as of lively disposition, and was then taken by Dr. Howe to Boston, U.S, where for twenty years she pursued her studies, and was enabled to speak readily and rapidly by signs, to read books written in the raised characters of the blind, and to write letters. In teaching her, Dr. Howe selected articles, such as a pin, spoon, pen, and key, the names of which were monosyllabic. Laura felt the articles, and then felt her instructor's finger, as he traced the letters of the name on the raised alphabet. In this way the letter-signs became familiar, and were associated with the things indicated; so that ultimately she could select the letters and place them in order as the name of the object indicated. After a time the principle of imitation which had hitherto alone guided her was replaced by the use of written language. She began to form abstract ideas, to think of the qualities and shapes of things as apart from the things themselves, and hence arose the perfect exercise of a language which, though spoken through signs, was nevertheless a true and typically human method of using ideas and concepts as a means of communication and expression. One of the most interesting observations in this case was that, when asleep and dreaming, Laura Bridgman spoke on her fingers, as she did when involved in a reverie and when thinking alone; such a fact demonstrating anew the conten-

tion that language is a necessary concomitant of perfect thought, even when it can only be indirectly expressed in signs and symbols. The interest which centres around such a case as the preceding is not limited to the lesson it conveys regarding the possibility of educating and evolving perceptions and language from a state of mind compared with which the concepts of an intelligent dog are vastly superior. Such a case also brings forcibly before us the consideration, that if, in face of the possession of a truly human brain, the faculty of language may be perfectly lapsed—as in the deaf mute—it may not, conversely, be accounted a more wonderful fact that changes of an opposite nature, resulting in increased growth of brain-power acting upon the organ of voice, should have evolved language from the germs of sound, sign, and gesture, in which it was potentially contained.

"Imagine," says a philosopher of a school given to denying the evolutionary view of things, in a recent work on "Mind and Brain," "this experiment (alluding to the imitative action of the lips in a deaf mute) tried with a monkey, the most imitative in action, or with a dog, the most intelligent of animals!" If this author's declaration is meant to indicate the impossibility of teaching either animal to form words, we quite agree with his expression of ridicule—with this difference, however, that we should transfer the expression to the philosopher who supposed that any one conversant with the matter could have argued as to the possibility of educating ape or dog. This is "barking up the wrong tree" with a vengeance. Evolution postulates no such absurdity; and Mr. Darwin is careful to note that "the mental powers in some progenitor of man must have been more highly developed than in any existing ape, before even the most imperfect form of speech could have come into use." It is well to note the latter opinion, because the chief point at issue, namely, the origin of language from the simple sounds and signs of long ago, is so frequently discussed upon grounds which are very far from representing the true state of scientific opinion on this subject. Over and over again one may meet with the argument, that the mental belongings of man are immeasurably above those of the highest apes, and that therefore the whole edifice, founded upon the presumed origin of man and human instincts from lower forms and states, must fall to the ground before the mention of the fact. Almost as relevant to the point at issue would it be to maintain that man had in his early days attended a meeting of the deities, and being, to quote the words of Moth, "at a great feast of languages," had "stolen the scraps."

To the assertion repeated *ad nauseam* by unscientific critics, that the brain-power of the highest apes is vastly inferior to that

of man, we reply, *Quis negavit?* Only those ignorant of what evolution implies, could for a moment credit the upholders of that explanation of the origin of man with holding such an opinion. What is more to the purpose, is the task of investigating the question whether or not there may be such likenesses between primitive tongues and between the mental states of the lowest sane men, insane or idiotic men, and of brutes, as to warrant the belief that allowing for steps in the transition, now indistinct or absent, the higher phases of mind and language have been evolved from the instincts and emotions of lower life. The arguments drawn from what we observe at present in lower life, and from what we see in lower human existence to-day, are eloquent in their support of the belief, that it is easier to assume such a development of language, than to assent to its supernatural and occult origin. Nor does a full consideration of human existence in its various phases militate against the evolutionist's views. Take, for instance, the extended period of human infancy, as compared with that of other animals, in its influences upon the development of the higher intellectual powers of man, the importance of such a consideration being specially insisted upon by Mr. Fiske. Says this author :—"The increase of intelligence in complexity and specialty involves a lengthening of the period during which the nervous connections involved in ordinary adjustments are becoming organised ; . . . the fact remains undeniable, that while the nervous connections accompanying a simple intelligence are already organised at birth, the nervous connections accompanying a complex intelligence are chiefly organised after birth." And again : "This period, which only begins to exist when the intelligence is considerably complex, becomes longer and longer as the intelligence increases in complexity. In the human race it is much longer than in any other race of mammals, and it is much longer in the civilised man than in the savage. Indeed, among the educated classes of civilised society its average duration may be said to be rather more than a quarter of a century, since during all this time those who live by brain-work are simply acquiring the capacity to do so, and are usually supported upon the products of parental labour."

Thus mankind, entering upon a long period of infancy, claims time for the formation of new habits of brain, new combinations of nervous acts. Whatever may be thought of this idea in its application to other phases of human evolution, there can be no doubt that its influence has been most marked in inducing the growth of new mental powers in man. It is in some such soil, and surrounded by some such conditions favourable to the growth of new ideas, that the germs of language may be reasonably supposed to have first made their appearance. The real difficulty attending the

question is to account for the first beginnings of association betwixt objects and corresponding vocal sounds. In the origin of language, as in many matters of later human existence, it is really *le premier pas qui coûte.* The bare consideration of usefulness and advantage would be a more than sufficient reason for explaining why the habit of associating objects and sounds should gain in strength and persistence as time passed; whilst, as the gregarious habits of early man in turn became fixed and paramount, such habit would acquire new force, and influence man's mental powers with cumulative effect. If thus we may not solve the mystery which surrounds even the theoretical beginnings of language, we may yet sufficiently approach the environs of the subject to declare with certitude that the growth of this "crowning mercy" of human life has not lain outside those laws of development which alone profess to lead us towards a conception of the "how" of living nature in other and widely different aspects. Not only in the intelligence of which language is one outcome, has man sped far ahead of his Simian neighbours. The results which lower brains, such as those of our canine friends, may accomplish in their way, may teach us the ends to which the development of a higher and more plastic mental organisation, under the benign influences of an extended infancy, may lead. Mind-development, indeed, appears ever to have been favoured over mere physical growth. It is in virtue of this law that the gorilla and the prizefighter, excelling *homo sapiens* of the purest type in brute strength, are nevertheless well-nigh on a par when their share of this world's highest aims and excellences are compared with his. Such a comparison is, perhaps, after all by no means an unjust one; inasmuch as it leads us to perceive some of the more prominent qualities and powers which have led man upwards to fulness of life, from the first beginnings and from the dim childhood of his race.

X.

BODY AND MIND.

PERHAPS no fact of scientific advance is fraught with deeper meaning than that which demonstrates to us the large amount of knowledge which recent research has been the means of throwing upon the functions of the brain. The domain of mind, it is true, must ever remain in many of its aspects a veritable arcanum, whose mysteries may never fall within the grasp of erudition and research. But the modern investigator has, at the same time, passed beyond the old boundaries which were wont to deter his predecessors from inquiring into the manner in which mind and brain co-operated in the regulation of the body, and has advanced materially our understanding of many facts of brain function, which, but a few years ago, represented the fastnesses and inaccessible regions of knowledge. Nor are these gains of science unimportant, when viewed from the purely social side of things. Rescued from the domain of the unknown, such facts as those to which we refer repel those beliefs in the mysterious and occult which lie at the root of so much that is ignorant and of a vast deal that is superstitious even in these matter-of-fact days. When, for instance, "mesmerism," the "electro-biology" (high-sounding title!), and the phrenologies of the modern Cagliostros, with their "hocus-pocus science," as Macklin would have termed it, are resolved into so many abnormal actions of brain, and into so much pseudo-scientific jugglery, the world at large is unquestionably the gainer in respect of the new and rational light which has been thrown upon phases of mind. Or, when the hallucinations of the ghost-seer are proved to be subjects of physiological study, and when the production of his inverted mental images is capable of being duly explained on known principles of life-science, we may congratulate ourselves on having snatched another mystery from the charlatanism of ignorance, and on having expelled so much superstition from the world. Thus, judging even the most recondite study of mind from a rigidly utilitarian point of view, we may discover that its effects must leave their wholesome mark on the social life of our day, and on that of succeeding generations as well. The gains of knowledge are in fact amongst the saving clauses which are now and then added to the large and complex roll of the constitution of man.

It may be well to preface such a simple study of mind and body

as that on which we purpose now to enter by a glance at some of those general relations between the material frame and its immaterial emotions which serve to demonstrate the tacit harmony exhibited by the powers which rule and the subject that obeys. No facts of physiology stand out in bolder relief than those which deal with the common and united action of brain and body, in the ordinary affairs of every-day existence. So perfectly adjusted is this co-operation between body and mind we speak of, that in the vast majority of instances we ourselves—the very subjects of its action—may be utterly ignorant of the existence of any such league. Like the system of secret espionage which in its most perfect phases moves and lives with us and beside us all unsuspected and unknown, the operations which issue from the head-centre of our corporeal government may be absolutely hidden from us whilst continually we live and act under their behests. We literally take no thought for the morrow of our existence, because we are accustomed to have so much of that existence regulated independently of consciousness, and certainly without the exercise of will. The food upon which we subsist is inspected, so to speak, on its presentation to the senses; but its preparation, and its elaboration to form blood, are matters which are adjusted by that perfect system of control which the nerve-centre exercises over the commissariat department. Even before that food has become ours, we may experience unconscious or automatic action of the bodily processes, when, at the sight of the dainty, the salivary glands are stimulated to the manufacture of their fluid, and the "mouth waters"—the digestive act in question being but the natural, though somewhat ill-advised, prelude to the actual reception by the mouth of the desired morsel. The circulation through our body of the vital fluid, and the ceaseless thud of the central engine of the blood-flow, similarly remind us of active processes on the exact continuance of which our life depends, and which nevertheless are regulated apart from the will, and in greater part outside the bounds of waking knowledge.

The consideration of this practically uncontrolled continuance of these actions becomes, in one view at least, of highly gratifying nature—since it is within the bounds of probability that, were the control of such important processes a matter of unremitting attention, the exigencies of human life, by withdrawing our attention from their due regulation, might conduce to the premature ending of life itself, whilst sleep itself in such an event would be an impossible condition. In many other ways and fashions does the brief chronicle of the bodily rule bring forcibly before us the independence of our attention and consciousness in so far as the government of every-day existence is concerned. The morning walk to business through the crowded thoroughfares, when we are wrapt in the mantle of

deepest thought—with "eyes in the mind," although ostensibly bent on outward things—and when we find our steps guided harmoniously towards our appointed end, illustrates but another phase of the unconscious ruling of our lives. And the phenomena of the sleep-vigil, when, wrapt in the mantle of fancies and acted thoughts, we may walk fearlessly on the house-tops, show us in another fashion the action of active brain and body upon unconscious mind.

Thus it seems perfectly clear that in many of our daily actions we pass automatically through existence, dreaming no more than does the wound-up watch of the mechanism in virtue of which we execute our common movements, but regulated at the same time by an internal power which now and then asserts its sway over the vital machinery, as if to remind us that we possess the higher attributes of reason and will. If it be true, as we have shown, that over the bodily processes brain asserts an autocratic sway, it is equally noteworthy that under the influence of what, for want of a clearer term, we may call conscious mind, the automatic rigour and regularity of life may be suspended and overruled. Take as a fitting and as an interesting example the difference between the ordinary unconstrained action of the heart and its behaviour under the influence of mental emotion. If, as Cowper figuratively puts it,

> The heart
> May give a useful lesson to the head,

it is no less true physiologically that the head may occasionally give anything but a salutary lesson to the heart. It was Molière and Swift who, in their day, justly ridiculed, as physiology proves, the idea that the heart's regular action depended upon some mysterious "pulsific virtue." Within the heart's own substance—and it must be borne in mind the centre of the circulation is simply a hollow muscle—lie minute "sympathetic" nerves and nerve masses which govern its ordinary movements, and are responsible for its unconstrained working. The regular motions of the heart thus present little difficulty in the way of theoretically understanding their origin and continuance. As other muscles—such as those of the eyelids or of the breathing apparatus—possess a regular action, and are stimulated at more or less definite intervals, so the heart itself simply acts in obedience to the defined nervous stimulation it undergoes. But it so happens, that other two sets of nerves are concerned more or less intimately in the affairs of the heart. From the sympathetic system, an important nerve trunk enters into the heart's substance. This trunk is independent in nature of the sympathetic nerve masses which control the ordinary movements of the heart. But the system of nerves which owns the brain as its head, also possesses a share in the heart's regulation. Nerves are supplied to the organ from a very remarkable branch, which, with more respect for scien-

tific terminology, perhaps, than for the reader's feelings, we shall name the "pneumogastric" or "vagus" nerve. This latter nerve originates from the upper portion of the spinal cord, esteemed, and justly so, as the most sensitive and important of the brain centres. So much for an elementary lesson in the nervous supply of the heart; the outcome of such a study being, that the heart much resembles a conjoint railway station, in which three companies possess an interest, and whose lines enter the structure. The chief proprietors of the station are represented by the small sympathetic nerves and nerve-centres, which belong to the heart's own substance, whilst the fibres of the sympathetic nerve, and those of the pneumogastric nerve, represent the other lines that traverse the common territory, and affect the traffic carried on within its bounds.

Now, in the relations borne by these various nerves to the work and functions of the heart, we may find a very typical example of the dominance occasionally assumed by the mind over a function of the body which, under ordinary circumstances, is carried on without the control of the head-centre of the frame—just, indeed, as the head of a department may sometimes interfere with the placid way of life by means of which his efficient subordinates may discharge the duties they owe to the country at large. For, what has experimental physiology to say regarding the explanation of the effects of joy or sorrow, fear and anguish, and the general play of the passions on the heart? Under the influence of the emotions, the organ of the circulation is literally swayed beneath varying stimulation, just as in metaphor we describe it as responding to the conflicting thoughts, which, whilst they primarily affect the brain, yet in a secondary fashion rule the heart and other parts of the body. The trains of thought in fact despatch to the heart, along either or both of the nerve-lines already mentioned, portions of their influence, with varying and different effects. Take for instance the effects of fear upon the heart-throbs. Who has not experienced the stilling of the heart's action which a sudden shock induces? or that chilling sensation, accompanied by the sudden slowing of the pulses, which every poet has depicted as the first and most typical sign of the startled mind? Such a familiar result of strong emotion illustrates the effect of mind upon body in a fashion of all others most clear and intelligible. Here an "inhibitory" action has taken place, through the medium of the "pneumogastric" nerves. By irritating or stimulating these nerves, we may slow the heart's action, or may cause that action to cease. It is from some such source also, that the influence of fear, or of that emotion which holds us rapt "with bated breath," or which keeps us "breathless with adoration," proceeds. Like the action of the heart, the process of breathing responds to the will and sway of that mental counsellor

who may sometimes not over-wisely strain his authority, and abuse the prerogative with which he is invested. Similarly, "the sacred source of sympathetic tears" rests in the mental emotion and its effect upon the tear-glands of the eyes; and such unwonted stimulation of these latter organs has come to be associated with certain emotions as the most stable expression of their existence. In such a study we may well discover how the physical and material basis whereon the expression of the emotions rests, is in reality constituted by the action and interaction of like processes to these we have been considering. An inhibition conveyed from brain to heart, and its visible effects on the body, together form the outcome of emotion, or expression, which, by long repetition in the history of our race, has come to be recognised as a sure sign and symptom of the thoughts and ways of mind.

This inhibition of the heart and its action, however, is not the only influence which is brought to bear on the normal work of that organ. If it is slowed by fear, it is stimulated by joy; if it is chilled by anguish, it is quickened by hope; and if the pallid countenance be an index of the one set of emotions, no less is the flushed visage and mantling colour the true expression of the other. By what means are the trains of thought laden with the hopes and joys of life made to affect the heart? To what do

> Sensations sweet,
> Felt in the blood and felt along the heart,

owe their propagation and conveyance? The answer is found in a study of the sympathetic system of nerves and its influence on the circulation. Experiment and analogy clearly prove, that through these latter nerves, the pulses of joy affect the throbs of the heart, and quicken its pulsations. The sympathetic nerves are thus the antagonists of the inhibitory fibres before-mentioned, which slow the heart's action, and chill the pulses of life. True, they are not of such powerful kind, and their action is not of such marked character as that of the fibres which retard the throbs of the heart. Still, the influence of the lines along which the impulses which quicken its action run, is marked and distinct enough; and it may be logically enough conceived, that in the subject of the beaming eye, in whose breast hope ever renews her "flattering tale," the sympathetic impulses have acquired a power unknown to the mind harassed by continual fears. And in a manner similar to that in which the cheering influences of life pass to quicken the action of the heart, are there more visible expressions of the emotions produced, in the tell-tale blush and in the mantling colour. Donne gives vent to no mere poetic phantasy, but declares a veritable fact of physiology, when he declares, in his Funeral Elegy "On the Death of Mistress Drury," that

> We understood
> Her by her sight ; her pure and eloquent blood
> Spoke in her cheeks, and so distinctly wrought
> That we might almost say her body thought.

The natural blush is thus the offspring of the mind. Its physiological explanation is simple enough. A larger quantity of blood than usual is sent into the minute blood-vessels of the skin, these vessels being in a state of temporary relaxation, and having had withdrawn the natural stimulus to moderate contraction, which is part of their ordinary duty. In what way has the head of the department interfered with the ordinary routine of the body? The answer is supplied by the knowledge we have already gained respecting the control of the forces which provide for the due circulation of the vital fluid, and also by experimentation upon the rabbit's ear. When the sympathetic nerves are affected, the heart's action, as we have noted, is quickened, and a greater amount of blood is sent through the vessels. When we divide the sympathetic nerve which supplies the blood-vessels of the ear, these vessels become dilated, and the rabbit's ear exhibits the same phenomena seen in the blushing countenance of the human subject. On the sympathetic system, then, we must lay the burden of any complaints we have to make respecting the "damask cheek" of every-day life. And conversely, to the same lines of nerve which speed the heart's action we must give the credit of causing the pallid countenance of fear or despair. When the cut end of the sympathetic nerve in the rabbit's ear is irritated, we perceive the ear to become pale, and its temperature to decrease. This result arises from our conveying to the nerves of the blood vessels some stimulus resembling that we have deprived them of, so that they contract overmuch, and thus expel the blood from the surface over which they are distributed. But the slowing of the heart in the ordinary course of life is probably a matter with which the inhibitory nerves have to do, and thus upon the pneumogastric fibres we may rest the pale cast of the human face divine. Not to be passed over without remark, are the consequences to our health and physical well-being which flow from such overriding by the nervous system of the ordinary processes and acts of life. When an influenza, or some still more serious internal disturbance of our healthy equilibrium, occurs, we may trace the affection in question to the influence of cold on the skin (as in a chill) acting upon nerves which regulate the blood-vessels and their contraction. Thus, to descend from philosophy to broad utilitarianism, it is not the least important effect of studies dealing with the mechanism of body and mind, that they may explain to us with equal facility the *rationale* of the emotions or the reason why we "catch a cold."

The ordinary relations between body and mind may thus be

demonstrated by the study of some of the simplest actions of bodily mechanism. On the other hand, this relationship may be equally apparent, and may be even more forcibly shown in some of its less understood phases, by a reference to states which as a rule are known to the physiologist or physician alone. In proof of this fact let us note the effect of some strong mental impressions upon the physical constitution. Here we may meet with illustrations in themselves of literally wondrous nature, and which reveal a power of affecting the body through the mind such as would scarcely be deemed possible under well-nigh any circumstances. Some curious instances of the effects of ill-governed rage, of violent temper, and of fear, upon the frame may be first glanced at. Sir Astley Cooper long ago drew attention to the high importance of the mother preserving a quiet mind and demeanour during the care and nurture of her child. This authority illustrates his advice by several instances in which some remarkable and unknown effects appear to have been produced in the maternal frame by passion and by fright. An instance in point is given by Dr. Andrew Combe. A soldier was billeted in the house of a carpenter, and, having quarrelled with the latter, drew his sword to attack his host. The wife of the carpenter interposed, and, in an excited state, wrenched the sword from the soldier and broke it in pieces, the combatants being thereafter separated by the interference of the neighbours. Labouring under the strong excitement, the woman took up her infant from the cradle where it lay playing in perfect health, and gave it the breast. "In a few minutes," says the narrator, "the infant became restless, panted, and sank dead upon its mother's bosom. The physician who was instantly called in, found the child lying in the cradle, as if asleep, and with its features undisturbed; but all his resources were fruitless. It was irrecoverably gone."

In lower life also, it would seem that fear and rage possess a similar influence on the bodily secretions in inducing a deleterious or even deadly effect. A puppy has been known to die in convulsions on sucking its mother after she had been engaged in a fierce dispute with another dog. The effects of fear in modifying bodily processes have been exemplified in the case of the heart's action; but they receive an equally interesting illustration in the disturbing influence of fear upon the secretion of the saliva. As the mouth "waters" when the dainty morsel is perceived or even thought of, so the opposite effect may be induced under the influence of a nervous dread and fear. No better illustration of this last assertion is to be found than in the case of the Indian method of discovering a thief. The priest who presides at the ordeal in question necessarily, by his mere presence, induces in the mind a superstitious horror of discovery. The servants in the household being seated and duly warned of the infallibility of the procedure, are furnished each with a mouthful of

rice, which they are requested to retain in the mouth for a given time. At the expiry of the period the rice is examined, when it is generally found that in the case of the guilty person the morsel is as dry as when he received it, the rice of his fellows being duly moistened. The suspension of secretion under the influence of fear may not be of universal occurrence. It is conceivable and probable that a person of strong will, even although labouring under the conviction of conscious guilt, might successfully pass through the ordeal; but the essential hold of the operator is in the influence of fear and the terror of detection by a process which the guilty person equally with his innocent neighbours believes to be all-powerful for the designed end. The feeling of conscious innocence would tend to promote the flow of saliva, whilst that of guilt would produce the opposite effect. Thus the common complaint of feeling "out of sorts" under the influence of worry and vexation, is but an illustration, drawn from every-day existence, of the effects of mental irritation upon the ordinary functions of the body, and an impaired digestion may thus appear as the true product of a mental worry. John Hunter's words, that "there is not a natural action in the body, whether involuntary or voluntary, that may not be influenced by the peculiar state of the mind at the time," may be viewed in the light of a simple truism. And sagely Burton delivers himself in his "Anatomy of Melancholy," when he remarks, that "Imagination is the *medium defens* of passions, by whose means they work and produce many times prodigious effects; and as the phantasie is more or less intended or remitted and their humours disposed, so do perturbations move more or less, and make deeper impression."

Most persons have heard of the idea which attributes the occurrence of jaundice to some strong disgust experienced by the subject of the affection, which, as is well known, simply consists in suppression of the bile or secretion of the liver—although by physicians jaundice is viewed rather as a symptom of other affections than as constituting of itself a primary disease. The bile was accounted in the early days of physiological research one of the humours, wherein was stored black care, or that "green and yellow melancholy" of which Shakespeare speaks. The same ideas which referred the passions to the various organs of the body—and which still figuratively survive when we speak of "a fit of the spleen," of the "meditative spleen" of Wordsworth, or of the "heart" as base, wicked, grateful, or glad—assigned to the bile no very auspicious office as the generator of melancholy and brooding care. "Achilles hath no gall within his breast" is an Homeric expression, indicative of a belief in the absence of melancholy or fear in the hero; and Juvenal asks:—

Quid referam quanta siccum jecur ardeat ira?

referring anger to the liver as its seat. Even Solomon makes misguided passion to be typified by the "dart," which strikes through the liver of the unguarded subject; and Jeremiah similarly conveys the idea of intense grief in the metaphor, "my liver is poured upon the earth." These ideas have long since been exploded; but there remains with us the equally curious notion that the influence of the mind upon the body may extend so far as to produce the serious disturbance of function which results in jaundice. Is it not probable that upon some such notion respecting the causation of jaundice, the ancient belief regarding the connection between the bile and mental states depended? On some such belief hang Shakespeare's words:—

> Why should a man whose blood is warm within,
> Sit like his grandsire cut in alabaster?
> Sleep when he wakes? and creep into the jaundice
> By being peevish?

Unquestionably we may find very direct evidence of the near connection between mental states and suppressed secretions when we turn to medical records. An eminent authority in the practice of physic writes:—"Certainly the *pathemata mentis* play their assigned parts; fits of anger, and of fear, and of alarm have been presently followed by jaundice. . . . A young medical friend of mine had a severe attack of intense jaundice, which could be traced to nothing else than his great and needless anxiety about an approaching examination before the Censors' Board at the College of Physicians. There are scores of instances on record to the same effect." It seems thus in the highest degree probable that there exist between mental states and the functions of the liver, relations of the most intimate kind. It is, however, equally important to avoid the fallacy *post hoc ergo propter hoc.* As Dr. Carpenter remarks, "It is a prevalent, and perhaps not an ill-founded opinion, that melancholy and jealousy have a tendency to increase the quantity, and to vitiate the quality, of the biliary fluid; and amongst the causes of jaundice are usually set down the indulgence of the depressing emotions, or an access of sudden and violent passion. There can be no doubt, however, that a disordered state of the biliary secretion is frequently rather the cause than the consequence of a melancholic state of mind, the blood being sufficiently vitiated by a deficient elimination of bile, to have its due relations with the nervous system seriously disturbed, before any obvious indications of that deficiency make their appearance in the jaundiced aspect of the cutaneous surface."

Amongst the most remarkable effects of mental emotion in producing curious and well-nigh inexplicable changes in the bodily organisation, are those witnessed in the changes which the skin or hair may undergo under the influence of care and fear especially.

Take firstly the case of the effects of wrinkled care. If "care will kill a cat," as George Wither has it, despite the innumerable lives with which the feline nature is usually credited, it is also certain that the "ravell'd sleave of care" unquestionably affects the bodily processes more plainly and lastingly than any of the other emotions. What text has more frequently been made the subject of poetic comment than the lean body and worn visage encompassing the harassed soul? John Hunter has noted that even in the hen, the care attending the upbringing of her numerous progeny keeps her body lean and meagre. "A hen shall hatch her chickens," says the observant founder of modern physiology, "at which time she is very lean; if these chickens are taken from her she will soon get fat, but if they are allowed to stay with her, she will continue lean the whole time she is rearing them, although she is as well fed and eats as much as she would have done if she had had no chickens." Substitute the worries of business or the cares and exigencies of life for the chickens, and place mankind in the place of the bird, and the picture of the physiologist would read equally true.

The influences of fear or care upon the skin and hair are equally notable. The "Prisoner of Chillon's" is no fanciful case, but one which medicine may show is of tolerably common occurrence. Bichát, the physiologist, notes such a case. After a severe illness, often after mental worry or temporary insanity, the hair may change its hue in a gradual fashion towards the whiteness of age. And that "sudden fears" may

> Time outgo,
> And blanch at once the hair,

is also a plain experience of the physician. In times of peril, such as on the threat and expectation of an invasion, numerous cases of a sudden change of the colour of hair have been recorded. The late Professor Laycock mentions a singular case, in which a lady, after a severe attack of neuralgia occurring in the night, found in the morning that the inner portion of one eyebrow, and the eyelashes attached to the part in question, had become of a white colour. There seems every reason to believe in the correctness of Dr. Laycock's assertion, that the natural greyness of old age is connected with certain changes in nerve-centres and in the nerves which are connected with the hair-bulbs, and presumably, therefore, with the conditions regulating the nutrition of the hairs. If this view be correct, it certainly shows how extensive and widespread are the influences which emanate from the brain and nerve-centres as the head-quarters of mind. On the converse side of things, we must not fail to note that occasionally, in a perfectly natural fashion, and without any undue mental stimulus, the hair of the aged may exhibit all the luxuriance and characteristics of youth. An old gentleman, aged 75, says Dr. Tuke, whose bones even "were so

impregnated with a thorough disgust of the government of George the Fourth that he threw up a lucrative situation in one of the Royal yards," induced his youngest son to go and do likewise. This thoroughgoing Radical insisted, moreover, that his wife, aged 70, "toothless for years, and her hair as white as the snow on Mont Blanc, should accompany them to the land where God's creatures were permitted to inhale the pure, old, invigorating atmosphere of freedom. About six or seven years after their departure, a friend living in New York gave an excellent account of their proceedings. Not only could the old man puff away in glorious style, and the son do well as a portrait-painter, but old Mrs. —— had cut a new set of teeth, and *her poll was covered with a full crop of dark brown hair!*"

Some of the most remarkable results of an unusual mental stimulus upon the body, are witnessed in cases wherein specific diseases have not merely been simulated, but have actually been induced, by the lucid description of them in the hearing of the persons who became thus mysteriously affected. Lecturers on the practice of medicine in our universities and medical schools rarely, if ever, deliver a statutory course to their students without exemplifying the truth of the foregoing observation. The writer well remembers an instance in point, occurring in a class-fellow of his own who attended the practice of physic class with him. During and after the description of skin diseases, this student suffered extremely from skin irritation, induced by his too vivid realisation of the symptoms described by the lecturer. These uncomfortable morbid feelings culminated one day when the lecturer described the symptoms of a certain disease supposed to possess a special sphere of distribution in the northern parts of Great Britain. For days afterwards, the student was tormented by an uncomfortable and persistent itching between the fingers, which no treatment seemed to alleviate; but which passed away when an eruption of a simple type appeared on his hands, the latter induced by no known cause, but apparently as the result of the morbid mental influences to which he was subject. Not a session passes in our medical schools but the lecturer on physic has occasion to quiet the nervous fears of nervous students, who simulate in themselves the symptoms of heart disease, and require the gravest assurances that their fears are ungrounded, and that they have simply been studying with a morbid interest the lecturer's remarks on heart affections.

In his work entitled "De l'Imagination," Demaugeon tells us that Nebelius, lecturing one day upon intermittent fever, and lucidly describing ague, noticed one of his pupils to become pale, to shiver, and to exhibit at last all the symptoms of ague. This lad was laid up for a considerable period with a true attack of the fever in question, and recovered under the usual treatment for the disease. If,

however, it is found that the influence of the mind, and the vain imaginings of a morbid fancy, may induce disease, it is no less certain that a like action of the mind may occasionally cure an otherwise stubborn malady. No better illustrations of such cases can be cited than those in which a severe fright relieves a condition which may have resisted every effort of treatment. An attack of toothache not unfrequently disappears when we seat ourselves in the dentist's chair. A severe attack of the gout has been cured by the alarm raised consequent upon the house of the patient being set on fire; whilst more than one case of severe pain has been cured by the patient ignorantly swallowing the paper on which the surgeon's prescription was written instead of the prescription itself.

There can be little doubt that certain phases of the imagination possess a singular and at the same time valuable effect in inducing the removal of diseased conditions. It is not certainly a satisfactory use, when viewed from the moral side, of such knowledge, when we find that a vast number of the cures said to have been effected by the nostrums of quacks, are wrought in virtue of this influence of mind over body. The "faith-healing" Bethshans, and allied establishments for the cure of all diseases, grave or simple, by faith in the power of prayer, present in the light of this remark a study of physiological interest. Says Dr. Tuke, in the preface to his interesting and classical work on the "Influence of the Mind upon the Body," the medical reader should "copy nature in those interesting instances, occasionally occurring, of sudden recovery from the spontaneous action of some powerful moral cause, by employing the same force designedly, instead of leaving it to mere chance. The force is there," continues this author, "acting irregularly and capriciously. The question is whether it cannot be applied and guided with skill and wisdom by the physician. Again and again we exclaim, when some new nostrum, powerless in itself, effects a cure, 'It's only the imagination!' We attribute to this remarkable mental influence a power which ordinary medicines have failed to exert, and yet are content with a shrug of the shoulders to dismiss the circumstance from our minds without further thought. I want medical men who are in active practice to utilise this force—to yoke it to the car of the Son of Apollo, and, rescuing it from the eccentric orbits of quackery, force it to tread, with measured step, the orderly paths of legitimate medicine. 'Remember,' said Dr. Rush, in addressing medical students, 'how many of our most useful remedies have been discovered by quacks. . . . Medicine has its Pharisees as well as religion; but the spirit of this sect is as unfriendly to the advancement of medicine as it is to Christian charity.'"

These words are full of practical wisdom and sound common sense, and serve to explain the *modus operandi* of the nostrums

which flood the advertising columns of our newspapers, and appeal to our varied senses at well-nigh every turn of modern life. A patient, suffering from some intractable complaint, in which a hopelessness of cure forms no inconsiderable obstacle to the physician's efforts, procures some new nostrum. The very sight of the invariable string of testimonials inspires confidence. There are certain to be included in the list of cures similar cases to his own. He reads and believes; and the nostrum, possibly harmless as the bread pills prescribed by the physician for the hypochondriac, receives another tribute of grateful praise. The analogous case of Liebig, who, when a young man, had neglected to prepare for his master's visitors the nitrous oxide, or "laughing-gas" of the modern dentist, but filled the inhalers with atmospheric air instead, illustrates once again the power of faith. The common air produced all the symptoms of mild gaseous intoxication which the laughing-gas was expected to induce. Venturing within the region of household medicine and popular surgery, perhaps the charming away of warts presents us with another instance of the literally remarkable influence of the mind in modifying not merely physical states but bodily structures. Every "wise woman" in the remote districts of the country, to which the spread of educational sweetness and light has mostly confined such homely oracles, possesses a "charm" for driving away the excrescences in question. Even in the time of Lucian such female practitioners of a mild species of occult art were celebrated for their successful treatment of warts. Dr. Tuke gives a case in point, in which, through the effects of the imagination, even in a cultured person, the growths in question were made to disappear. A surgeon's daughter had about a dozen warts on her hands, the usual modes of treatment having availed nothing in their removal. For eighteen months, the warts remained intractable, until a gentleman, noticing the disfigurement, asked her to count them. Carefully and solemnly noting down their number, he then said, "You will not be troubled with your warts after next Sunday." At the time named, the warts had disappeared, and did not return. Here, the connection between the imaginative impression of some occult or mysterious power, and the cure, was too close to leave a doubt that, as in other cases of bodily ailment, the mind, which so frequently affects the body to its hurt, had in turn favourably influenced the physical organisation.

No less a personage than Lord Bacon himself had a similar cure performed upon his hands by the English Ambassador's lady at Paris, "who," he adds, "was a woman far from superstition." The lady's procedure certainly betokened a belief in some occult effects or influences, for Bacon tells us that, taking a piece of lard with the skin on, "she rubbed the warts all over with the fat side," and amongst the

growths so treated was one he had had from childhood. "Then," continues the narrative, "she nailed the piece of lard, with the fat towards the sun, upon a post of her chamber window, which was to the south. The success was that in five weeks' space all the warts went quite away, and that wart which I had so long endured for company. But at the rest I did little marvel," says Bacon, "because they came in a short time, and might go away in a short time again; but the going away of that which had stayed so long doth yet stick with me." The miscellaneous character of the substances used in wart charms and in incantations of like nature, at once reveals the fact of the real cure lying in some direction other than that of the nostrum. Beneath the material substance unconsciously used as a mere bait for the imagination, work the forces of mind acting through the medium of the nervous system. "The *confident expectation of a cure*," to use Dr. Carpenter's expression, is the most potent means of bringing it about; and, as another writer remarks, "Any system of treatment, however absurd, that can be 'puffed' into public notoriety for efficacy —any individual who, by accident or design, obtains a reputation for the possession of a special gift of healing—is certain to attract a multitude of sufferers, among whom will be several who are capable of being *really* benefited by a strong assurance of relief, whilst others for a time *believe* themselves to have experienced it. And there is, for the same reason," adds this author, "no religion that has attained a powerful hold on the minds of its votaries, which cannot boast its 'miracles' of this order."

The same spirit of popular belief and credulity which long ago asserted that vaccination produced a growth of "horns" on the heads of the vaccinated subjects, from their being inoculated with the matter obtained from the cow, was displayed in another but equally unreasoning fashion in the assertion that the touch of a royal hand could cure scrofula—a disease which to this day retains the popular name of "king's evil." Macaulay relates that when William III. refused to lend his hand and countenance to the cure of scrofula, evidence of overwhelming nature as to the multitude of cures which had been wrought by the royal touch was collected and submitted. The clergy testified to the reality of the effects induced, as in earlier years they had frequently been the chief propagators of superstitious myths concerning healing powers of occult nature, whilst the medical profession testified that the rapidity of the apparent cures placed them beyond the sphere of natural causation, and brought them within the domain of faith—a lack of which virtue resulted in failure to effect a cure. In the reign of Charles II. nearly one hundred thousand persons were "touched"; and King James, in Chester Cathedral, performed a similar service to eight hundred persons. On William the consequences of refusing to favour a popular delusion fell fast and heavy.

Jacobites and Whigs alike criticised his determination unfavourably; but in the era we speak of began the decline of the sovereign virtue of the royal touch—a virtue which is scarcely spoken of, much less demanded, in these latter days, which, however, countenance and support delusions of equally absurd kind. Dr. Tuke quotes a passage from Aubray to the effect that "The curing of the King's Evil, by the touch of the King, does much puzzle our philosophers, *for whether our kings were of the House of York or Lancaster*, it did the cure for the most part. In other words," adds Dr. Tuke, "the imagination belongs to no party, guild, or creed."

Within the domain of theology itself, the physiologist occasionally finds it his duty to intrude; since therefrom not a few illustrations of very remarkable kind respecting the influence of mind upon body, have been drawn. The more important do these instances become, because, from a moral point of view, their influence tends often to propagate as the "miracle" of the credulous, a condition or effect readily explicable upon scientific grounds. In convents, not merely have delusions resulting from diseased imagination been frequently represented, but such delusions have affected in various remarkable ways the bodies of the subjects in question, and have in turn extended their influence to others. Thus, for instance, a tendency to mew like a cat, seen in one inmate, has passed through an entire convent. One of the best known instances of a disordered imagination tending to propagate a delusion, is that given by Boerhaave, who was consulted with reference to an epidemic occurring in a convent, and which was characterised by a succession of severe fits. On the principle *similia similibus curantur* Boerhaave determined to repress the disordered and, for the time, "dominant idea," by another of practical kind, and accordingly announced his intention to use grave medical measures in the shape of a red-hot iron on the first patient who presented herself. Needless to remark, the dominant idea of the physician replaced that arising from the abnormal action of mind, and the peace of the convent was duly restored by this simple expedient.

One of the most familiar cases which occurred within recent times was that of Louise Lateau, a young Belgian peasant, whose mental aberrations, aided by some very singular bodily defects, gained for her the reputation of sanctity of a high order and uncommon origin. To begin with, Louise Lateau suffered from a protracted illness from which she recovered after receiving the Sacrament. Naturally enough, this circumstance alone affected her mind, and stamped her recovery as a somewhat supernatural, or at any rate as a highly extraordinary, occurrence. Soon thereafter blood began to flow from a particular spot on her side every Friday. A few months later, bleeding points, or *stigmata*, began

to appear on the palm and back of each hand. The upper surface of the feet also exhibited similar bleeding points, and on her brow a circle of spots also appeared, the markings thus coming to imitate closely the injuries familiar to all in connection with the Crucifixion. Every Friday these points bled anew, the health of the subject of these strange phenomena being visibly affected; whilst the mere nature of the condition was sufficient to stamp her case as peculiar in the highest degree. At the period when the *stigmata* began to be developed, Louise Lateau also commenced to exhibit that condition of mind universally known under the term "ecstasy." In this state, which might be described as that of abstraction *plus* rapture, the mind is removed from its surroundings, as in somnambulism or the mesmeric state. Louise Lateau, however, could, as in many cases of the mesmeric trance, describe after her return to consciousness the sensations she had experienced. She described minutely her experiences as consisting of the sensation of being plunged into an atmosphere of bright light from which various forms began to appear. The scenes of the Passion were then enacted before her, and every detail of the Crucifixion was related by her, down to a minute description of the spectators around the cross. The successive pictures which were being represented to her mind could be traced in her actions. Each emotion was accompanied by a corresponding movement, and at 3 P.M. she extended her limbs in the shape of a cross. After the ecstasy had passed away, extreme prostration followed; the pulse was feeble, breathing slow, and the surface of the body bedewed with a cold perspiration. In about ten minutes thereafter, she returned to her normal state.

Such is a brief recital of a case by no means unique in the history of physiology, but which demonstrates in a singular fashion how mind may act upon body in ways literally undreamt of. There is little wonder that Louise Lateau should have been regarded as a person around whom a special halo of sanctity had been miraculously thrown; whilst the peculiar fashion in which her body seemed to follow the dreams or visions of her ecstasy in the production of seeming duplicates of the injuries to the crucified body, served but to raise the occurrence to a higher level of the miraculous. Such ecstatic states, however, are well known in the history of science. Maury points out that supernatural revelations were not the exclusive property of the good, but appeared to the sinful likewise. Visions of demoniacal scenes were once as frequent as dreams of heaven, and hence it became necessary, as the last-named author points out, to classify these occurrences as "holy" and "demoniacal." St. Francis d'Assisi was the parent of these "stigmatic" visitations; and M. Maury relates that saints' days and Fridays were the occasions on which the "stigmata" almost universally appeared—a fact

illustrated by such cases as those of Ursula Aguir (1592), and Sister Emmerich (1824). Here, again, we have to face simply the oft-repeated problem of the potent influence of mind over a special region or part of the body, resulting from the extreme concentration of the attention upon special features or objects of adoration or worship. Emotional excitement produces cases allied to those of the "stigmatics" of religion, under circumstances which suggest a common causation for both. In the case of a sailor related by Paulini, large drops of perspiration of a bright red colour appeared on the face, neck, and breast, after a severe fright. The man was speechless from mental excitement, but as the bleeding points disappeared the man recovered his speech. This case presents us with the phenomena of Louise Lateau, the stigmatic, separated from the halo of inspiration by which she was surrounded, but induced by a like cause—the abnormal, concentrated, and unconscious action of the imagination upon the circulation. No less interesting is the occurrence of a similar phenomenon in lower life, in the august person of a hippopotamus, which in a fit of rage was noted by the late Mr. Frank Buckland to perspire profusely a fluid containing blood. This latter fact serves to demonstrate not merely the community of these phenomena in man and animals, but also divests the occurrence of that miraculous or occult nature which human credulity or superstition, under certain circumstances, would assuredly attribute to it.

XI.

THE OLD PHRENOLOGY AND THE NEW.

THERE has ever lain a strange fascination for culture and ignorance alike, in the attempt to diagnose the intellect and character of man from the outward manifestations of his face and skull. The problem of character and its interpretation is as old as Plato, and may probably be shown to be more ancient still. Egyptian soothsayers and Babylonian astrologers were hardly likely to have omitted the indexing of character as a profitable and at the same time legitimate exercise of their art. The forecasting of future events and the casting of nativities were studies likely enough to bear a friendly relationship to the determination of character from face, from fingers, or from skull and brain itself. But the histories of palmistry and soothsaying, with that of physiognomy, are they not all writ in the Encyclopædias? We shall not occupy space with an historical *résumé* of the efforts of philosophy in swaddling clothes attempting to wrestle with the great problem of mind and matter; nor shall we at present venture to oppose a scientific denial to Shakespeare's dictum that

> There's no art
> To find the mind's construction in the face.

Darwin's "Expression of the Emotions," the development of facial contortions, and the interesting study of the genesis of smiles and tears, and of the thousand and one signs which make up the visible and emotional life of humanity, may form a subject for treatment hereafter. Our present study concerns the deeper but not less interesting problem of the indexing of mind, and of the relations of brain-conformation and brain-structure to character and disposition. If there exists no art "to find the mind's construction in the face," Lavater notwithstanding, may we discover "the mind's construction in the skull"? If the old phrenology, or the science of brain-pans, be regarded as practically obsolete amongst physiologists and scientific men at large, what hopes of successfully estimating the "coinage of the brain" may the new phrenology be said to hold out? To this interesting question, then, let us ask the reader's attention for a brief period. We may premise, that if the march in ways phrenological be somewhat bellicose, our journey shall not be wanting in those mental elements which make for instruction in a field largely peopled with human hopes and fears.

The professions of phrenology are not by any means so correctly appreciated as might be thought, considering how well known is the name of the science, and how popular were its tenets within, comparatively speaking, a few years back. Although the name "phrenology" is but an echo in the scientific class-rooms, its professors still flourish, mostly in obscure localities in large towns, and often present themselves as modern representatives of the Peripatetici, in that they wander from town to town as travelling philosophers who usually unite a little electro-biology to their phrenological talents, and throw in an occasional mesmeric *séance* by way of offset to the more serious business of the interpretation of character. There are, it is true, phrenological societies and museums in several of our cities. The latter are chiefly remarkable for the varied collection of murderers' effigies and for the extensive assortment of casts of cranial abnormalities; the exact relationship of these contorted images to phrenological science being rarely if ever made clear to the visitor on the search for knowledge. Now and then in opticians' windows one sees a wondrous china head whose cubic capacity is mapped off into square inches, half inches, and quarters, of veneration, ideality, comparison, benevolence, and many other so-called "organs" of mind. The contemplation of such a work of art excites within the mind of the ingenuous observer an idea of the literal awfulness of a science which dispenses destructiveness by the inch, and which maps out the bounds of our amativeness by the rule of three; whilst the profundity of its professors may by such a mind be compared only to that of Butler's *savant* who

> Could distinguish and divide
> A hair, 'twixt south and south-west side.

Nor would the admiration of the ingenuous one be lessened were he to enter the sanctum of the "professor" of phrenology, and submit his cranium to the ocular inspection and digital manipulation of the oracle. The very furnishings of the apartment are often of mystic order, and are calculated to impress or overawe the inquiring mind. Pope's dictum concerning "the proper study of mankind" embellishes the walls; and the advice "know thyself," (meant to be interpreted and taken in a phrenological sense,) is given gratis through the medium of a conspicuous, and usually illustrated, poster. The tattooed head of a New Zealander; a few skulls, occasionally supplemented by a collection of stuffed lizards and other reptilian curiosities, and invariably flanked by busts of the ancient philosophers, complete the æsthetic furnishings of the modern temple of the delineator of character. To the proprietor, in due time, enters a certain moiety of the British public in search of knowledge. And thence in due season issue the clients of the professor of brain-pans, each pro-

vided (for a consideration) with a wondrous chart of their mental disposition, wherein the moral quicksands are presumed to be duly marked, and the obliquities of character stamped, with a view towards future correction and improvement.

How may the phrenological professor succeed very fairly in reading character? may be asked at the outset by readers who have had those parts of their disposition best known to themselves delineated with a fair approach to accuracy by the oracle. The reply is clear. Not through manipulating those mysterious "bumps," nor through any occult knowledge of the brains of his votaries, but simply from a shrewd talent for scanning the personal appearance and physiognomy of his clients, and by the dexterous suggestion of queries bearing on those traits of character which the features and manner reveal. Your successful phrenologist is in truth a shrewd physiognomist. His guide to character is in reality the face, not the brain-pan. The dress, manners, and deportment of his clients, and not the grey matter of the cerebrum, form the real basis of his observations. If any one may be found to doubt how accurately one's character may be mapped out from its outward manifestations, let him endeavour to study for a while the acts and deportment of those with whose "mind's construction" he may be even slightly acquainted, and he will speedily discover numerous clues to the mental disposition in common acts and traits which previously had passed utterly unnoticed. Such a result accrues speedily to the professed physiognomist and shrewd observer of men, who, passing his fellows in professional review before him, speedily discovers types of character to which, with allowance for special proclivities or traits, his various clients may be referred. That character may with tolerable success be determined even from handwriting, is a well-known fact; and it is difficult to see the superiority of the pretensions and claims of phrenology as a guide to character over those of the professor of caligraphic philosophy. One of the most convincing illustrations that even a practical knowledge of brain-structure is not necessary for the successful delineation of such superficial traits of character as can alone be determined by the casual observer, may be found in the fact, that very few "professors" of phrenology have undergone any training in physiology, whilst a large proportion may never have seen an actual human brain. A notable example of a successful practice of phrenology being carried on independently of any knowledge whatever of the brain, was known to the writer, in the case of a worthy police-sergeant, who attained tolerable accuracy in the art of reading "the mind's construction," but who had never even seen a brain, and who had the faintest possible idea of the appearance of that organ. Unless, therefore, one may logically maintain that ignorance of the furthest and

latest science brain-pan is compatible with an accurate understanding of its contents and mysteries, the successful practice of phrenology must be shown to depend on other data and other circumstances than are supplied by anatomy and physiology—these sciences admittedly supplying the foundation of all that is or can be known regarding the brain, its conformation, structure, and functions. It is, at any rate, a somewhat astounding proposition as modestly advanced by the phrenologists themselves, that they alone possess the clues to the true functions of the brain; while the researches and labours of the most accomplished physiologists and neurologists, living and dead—Fritsch, Hitzig, Ferrier, Broca, Charcot, and a score of others—are to be regarded as of no account when set against the crude "science" of the charlatans who delineate a fanciful mosaic of mind on the outside of the skull. Empirical science—science falsely so called—will not hesitate to assert its ability to accurately solve the deepest problems of character and mind. But the more modest spirit of the true scientist will hesitate before crediting itself with any such ability, or even before giving assent to such general rules of character as are exemplified by the saying, "Big head and little wit;" or by that of the worthy Fuller, who, in his "Holy and Profane State," remarks that "Often the cockloft is empty in those whom Nature hath built many stories high."

The fundamental doctrine of the old phrenology is well known to most of us. Its great doctrine is pictorially illustrated in the china heads of the optician's windows, and may be summed up in the statement that different parts or portions of the brain's surface represent the organs of different faculties of mind. The brain thus viewed is a storehouse of faculties and qualities, each faculty possessing a dominion and sphere of its own amongst the cerebral substance, and having its confines as rigidly defined as are the boundaries of certain actual provinces in the East, the status of which has afforded matter for serious comment of late amongst the nations at large. Thus, if phrenology be credited with materialising mind in the grossest possible fashion, its votaries have themselves and their science to thank for the aspersion. If it be maintained that feelings of *destructiveness* reside somewhere above the ear, then must we localise the desire to kill or destroy in so much brain-substance as lies included in the "bump" or "organ" in question. When we are given to gluttony and high living, we are asked to believe that it is the excess of brain-matter placed in front of the ear, and constituting the bump of "alimentiveness" that incites to the life and acts of the *gourmand*. When vainglory besets us, we must hold, if we are phrenologists, that there is a molecular stirrage and activity of brain-particles beneath a certain bump of "self-esteem" situated

somewhere about the vertex of the skull. Feelings of veneration, of hope, or of wonder are each to be regarded as causing a defined play of action in particular bumps and special quarters of the brain.

Nay more; in a chart of a phrenological professor which lies before me, I discover among the areas set forth a bump of "human nature"—whatever that expression may be taken to mean—another of "inhabitiveness," said to mean "love of home"; another of "mirthfulness"; another of "marvellousness" or "spirituality"; and yet another remarkable "organ" of "agreeableness." It would seem that each phrenologist differs from his neighbours in respect of the number of "organs" into which the brain's surface is capable of being mapped out. This multiplication of qualities or propensities is perchance not wonderful, seeing that as far as the reality of the deductions is concerned, it matters not how many "bumps" can be conglomerated on the china bust or chart of the professor of phrenology. When, however, one finds an organ of "form" placed somewhere about the top of the nose, one of "language" at or about the eye, and a whole series of small areas over the eye, mapped out into organs of "size," "order," "colour," "weight," and "calculation," it is high time for common sense to step in and to inquire how it comes to pass that, in these days of educational advance, any person short of qualifying for graduation in quackery, can believe that the workings of mind should be capable of being construed through thickness of skin and bone, upon minute areas of the head, many of which have no direct connection at all with the brain-surface, and not one of which, be it added, can be shown to possess any existence at all in the brain itself.

Were the deductions of phrenology true, or were its claims to be regarded as a science founded on definite grounds, mind could no longer be regarded as a mystery, since it would be within the power of the phrenologist to assert that, when swayed by emotions of one kind or another, he could declare which part of the brain was being affected. This declaration logically follows upon that which maintains the localisation of faculties in different parts of the brain; but it is a conclusion at the same time from which physiology simply retires in outspoken disdain, as presenting us with an empirical explanation of mysteries to which the furthest science has as yet failed to attain.

That we may duly understand, not merely the falsity of the old phrenology, but the bearings of the new aspects of brain-science as revealed by modern physiology, we must briefly glance at the general conformation of the brain. The organ of mind, contained within the skull, and as seen in a superficial view of things, consists of the greater brain or *cerebrum* (fig. 23, AA), and the lesser brain or *cerebellum* (B).

The latter portion is situated at the back of the head, and forms the hinder part of the brain; the spinal cord (c), which, as every one knows, runs through the spine (vv), being merely a continuation of the nervous centres of which the brain is the chief. In addition to the cerebrum and cerebellum the brain, it may be noted, consists of several very distinct masses of nervous matter, or "centres," each possessing definite functions of its own. A brain, so far from being a single organ, is in reality a collection of nerve-centres, yet the phrenologists speak of it as if it consisted of the two parts above noted alone. When the surface of the cerebrum is inspected, it is seen to present a very unequal appearance, due to the fact that its substance is thrown into a large number of folds or *convolutions* (see fig. 23), as they are technically named by the anatomist. The cerebrum, however, is in reality a double organ, formed of two similar halves or *hemispheres*, which are separated by a deep central fissure, but which are also connected together below by a broad band of nervous matter known as the *corpus callosum*. It is this latter band which, in addition apparently to discharging other functions, performs the duty of bringing the halves of the cerebrum into relation with one another, and thus serves to produce identity and correlation of action between its various parts.

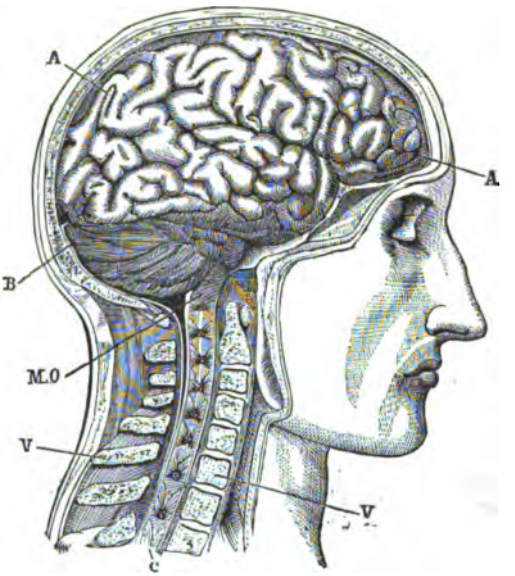

FIG. 23.—SIDE VIEW OF THE BRAIN AND SPINAL CORD.—(From Bourgery). A, the cerebrum; B, the cerebellum; M.O., the medulla oblongata; V, the vertebræ, cut in halves; C, the spinal cord, and the origin of its nerves.

To the nature of the "convolutions" our especial attention must be directed. The brain-substance consists of grey and white nervous matter. The grey matter forms the outermost layer of the brain-substance, and encloses the white; the opposite arrangement being seen, curiously enough, in the spinal cord. Now, one evident purpose

of the convolutions of the brain is to largely increase the amount of its grey matter relatively to the space in which the organ of mind is contained; whilst the perfect nutrition of the brain is also thus provided for through its convoluted structure permitting a fuller distribution of the minute bloodvessels which supply the brain with the vital fluid. It is a very noteworthy fact that the structure of the grey matter differs materially from that of the white. In the grey matter *nerve-cells* are found in addition to nervous *fibres*. The *cells* originate nervous force, whilst the *fibres* are simply capable of conveying this subtle force. Thus it may be said that it is in the grey matter that thought is evolved, and from this layer that purposive actions spring. The white matter, on the other hand, merely conveys nerve-force and nervous impressions, and is thus physiologically inferior in its nature to the grey substance.

The observations of Gratiolet, Marshall, and Wagner seem to leave no room for doubt that the convolutions of the brain increase with culture, and are therefore more numerous and deeper in civilised than in savage races of men. It is curious, however, to observe that certain groups of quadrupeds are normally "smooth-brained," and possess few or no convolutions. Such are rats, mice, and the rodents or "gnawing" animals at large. It can hardly be maintained that in these animals intelligence is normally low or instinct primitive—although, indeed, the just comparison of human with lower instincts must be founded on a broader basis than is presented by this single anatomical fact.

A final observation concerning the anatomy of the brain relates to its size and weight as connected with the intelligence. The phrenological doctrine of the disposition of faculties must be held to include the idea, that the larger the brain, the better specialised should be the mental qualities of the individual. The greater the amount of brain-substance forming the good and bad qualities and regions of the phrenologist, the more active should be the mental organisation. Now, it is a patent fact that this rule tells strongly against the phrenologist's assumption. True, various great men have had large brains; but cases of great men possessing small brains are equally common, as also are instances where insanity and idiocy were associated with brains of large size. The normal average human male brain weighs from 49 to 50 ounces; man's brain being 10 per cent. heavier than that of woman. Cuvier's brain weighed 64½ ounces; that of Dr. Abercrombie 63 ounces; that of Spurzheim, of phrenological fame, 55 ounces; Professor Goodsir's brain attained a weight of 57½ ounces; Sir J. Y. Simpson's weighed 54 ounces; that of Agassiz 53·4 ounces; and that of Dr. Chalmers 53 ounces. As instances of high brain-weights, without corresponding intellectual endowment, may be mentioned four brains weighed by Peacock, the

weights of which varied from 67·5 to 61 ounces. Several insane persons have had brains of 64½ ounces, 62 ounces, 61 ounces, and 60 ounces, as related by Bucknill, Thurnam, and others. With respect to the brain-weights of the fair sex, anatomical authority asserts that in women with brains weighing 55·25 ounces and 50 ounces, no marked intellectual features were noted. Below 30 ounces, the human brain becomes idiotic in character, so that there appears to exist a minimum weight, below which rational mental action is unknown. The anatomist's conclusions regarding brain capacity and mental endowments are therefore plain. He maintains that the size and weight of the organ do not of themselves afford any reliable grounds for an estimate of the mental endowments, whilst his researches also prove that a large brain and high intellectual powers are not necessarily or invariably associated together. It is quality, not quantity, in other words, which determines mental capacity.

The foregoing details will be found to assist us in our criticism of the pretensions of the old phrenology as a basis for estimating "the mind's construction" and the mental habits of man. Primarily, let us enquire if *development*—that great criterion of the nature of living structure—lends any countenance to the idea that the brain is a collection of organs such as the phrenologist asserts it to be. The brain of man, like that of all other backboned animals, appears to begin its history in a certain delicate streak or furrow which is developed on the surface of the developing germ. Within this furrow the brain and spinal cord are at first represented by an elongated strip of nervous matter, which strip, as the furrow closes to from a tube, also becomes tubular, and encloses within it, as the hollow of the tube, the little canal which persists in the centre of the spinal cord. The front part of this nervous tube, which soon exhibits a division into grey and white matter, now begins to expand so as to form three swellings named *vesicles*. From these three vesicles the brain and its parts are formed. The foremost swelling soon produces the parts known as the optic lobes, and also the structures which are destined to form the hemispheres or halves of the cerebrum itself. The middle swelling contributes to the formation of certain important structures of the brain; and finally the cerebellum or lesser brain, along with the upper part of the spinal cord and other structures, appear as the result of the full development of the hinder or third swelling. Nor must we neglect to note that at first the human brain is completely smooth and destitute of convulsions, and only acquires its convoluted appearance towards the completion of development.

It is now an appropriate duty to enquire if the history of the brain's growth affords any countenance or support to its phrenological division into the different organs and seats of faculties. The

query is further a perfectly legitimate one. The phrenologist maintains the actuality of his deductions respecting the "organs" of mind, and it is only a fair and just expectation that, if the brain be a congeries of such organs, the anatomist should be able to see these parts as development has revealed them. The nature of the brain is asserted by the phrenologist to exist in its composition as a set of organs. That nature, argues the anatomist, if revealed at all, should present itself in its development, which alone can show us nature's true fashion of building a brain. What, therefore, is the result of the anatomist's study of the manner in which the brain is fashioned? The answer is found in the statement that there is not a trace of a single "organ" such as the phrenologist theoretically maintains is represented in the brain. There is no division into separate parts and portions, as the phrenologist's chart would lead the observer to suppose. The scalpel of the anatomist can nowhere discover in the full-grown brain an organ of veneration, or of hope, or of language, or of destructiveness, or of any other mental feature: nor can his microscope detect in nature's wondrous process of fashioning the brain any reason for the belief that the organ of mind is a collection of parts, each devoted to the exercise of a special quality of mind. The arrangement which appears so clear on the phrenologist's bust is nowhere represented in the brain itself; and the organs of the phrenologist, in so far as their existence is concerned, may not inaptly be described in Butler's words as being

> Such as take lodgings in a head
> That's to be let unfurnished.

But if development gives no support to the phrenological assertion of the brain's division into organs of the mind, neither does anatomy, human or comparative, countenance its tenets as applied to the examination of the brain-pan itself. To select a very plain method of testing the deductions of phrenology, let an anatomical plate of the upper surface of the undisturbed brain be exhibited, and having settled the position of certain "organs" on a phrenological chart, let any one try to discover if the limits of any one organ can be discerned on the brain-surface. He will then clearly appreciate the hopeless nature of the task he has undertaken, and be ready to shrink from the attempt to resolve the complex convulsions before him into a square inch here of one faculty, or a square inch there of another.

Moreover, one very important consideration will dawn upon the reflective mind which considers that the convolutions of the brain are not limited to the crown and sides of the head, but, on the contrary, extend over the entire surface of the cerebrum, and are developed also on its base (see fig. 24). No phrenologist has attempted, it is true, to get at the base of the brain by inspecting the palate; but

it would be regarded as an absurd and unwarrantable statement to assert that the base of the brain has no functions, and that the nervous acts of man spring only from the top and from the sides of the head. Yet the phrenologist is in the position of one making such an assertion; since his science takes no account of the base or internal parts of the brain—situations, forsooth, in which anatomy and the newer phrenology demonstrate the existence of very important organs.

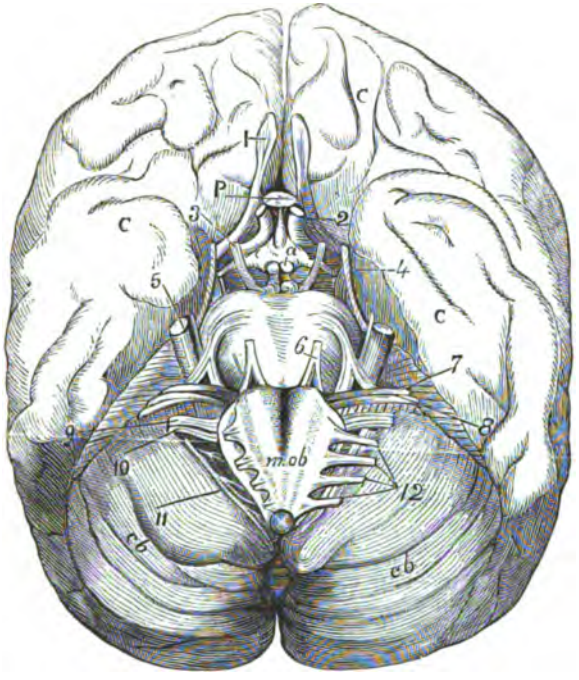

FIG. 24.—THE BASE OF THE BRAIN.—(From Bourgery). C, under-surface of the cerebrum; *cb*, the cerebellum; *m. ob*, the medulla oblongata. The nerves are numbered 1 to 12. 1, the olfactory nerve; 2, the optic; 3, 4, and 6, nerves which govern the muscles of the eyeball; 5, the trigeminal, which arises as shown by two roots; 7, the facial; 8, the auditory; 9, the glosso-pharyngeal; 10, the pneumogastric; 11, the spinal accessory; 12, the several roots of the hypoglossal. The figure 6 is placed on the pons varolii; the crura cerebri are between the third and fourth nerves on either side. Just above are *a*, the corpora albicanta, and P, the pituitary body.

The question of the relatively immense tracts of brain which lie without the utmost ken of phrenology, even on its own showing, is also illustrated by the observation, that the bulging or hollowing of the skull at any point affords no criterion of the thickness of the grey

matter of the brain, a layer which we have already seen to constitute the most important part of the brain-substance. This grey matter is seen to exist in tolerable uniformity over large tracts of brain-substance, and it is invariably in the hinder region of the brain that it attains its greatest complexity and development. The form of the skull is dependent on the amount and disposition of the white matter, and not on that of the grey; and the former, as we have seen, has but a minor influence or part in the mental constitution, since its function is merely that of conducting, and not of originating thoughts and impressions. Since, then, phrenology lays so much stress on skull-conformation as a clue to brain-structure, it must be regarded as dealing rather with the results of the disposition of the white matter than with that of the grey—and this latter assumption of necessity involves a second, namely, that phrenology has no status as a science of mind at all.

There is one consideration concerning the practical application of the phrenologist's assertions too important to be overlooked, namely, the difficulty of detecting or of mapping out on the living head the various "bumps" or organs of mind which appear to be so lucidly localised on the bust or chart. The observer, who might naturally think the determination of the "bumps" an easy matter, has but to try to reconcile with a phrenological chart or with the brain-surface itself (fig. 23), the configuration of a friend's cranium, and he will then discover the impossibility of distinguishing where one faculty or organ ends and where another begins. How, for instance, can the exact limits of the four or five organs of mind, to be hereafter alluded to more specifically, which are supposed to exist in the line of the eyebrow, be determined? What is the criterion of excessive or inferior development here, and how may we know when one "encroaches" upon another to the exclusion, or atrophy of the latter? The practical and exact application of phrenology indeed constitutes one of its gravest difficulties. Added to the difficulty or impossibility of accurately mapping out the boundaries of the phrenologist's organs, we must take into account the fact that we are expected to detail these organs through, in any case, a considerable thickness of scalp, which veils and occludes, as every anatomist knows, the intimate conformation of the skull-cap. At the most, the phrenologist may distinguish regions; his exact examination of the living head *à la* the phrenological chart or bust, is an anatomical impossibility.

But the anatomist has also something of importance to say regarding the actual existence of certain of the "organs" of mind mapped out by the phrenologist. Leaning trustfully upon their empirical deductions, the phrenologists have frequently localised faculties and organs of mind upon mere bony surfaces separated from the brain by

an intervening space of considerable kind. In so far as comparative anatomy is concerned, phrenology receives no assistance in its attempt to localise mind-functions in man. An elephant is admittedly a sagacious animal, with a brain worth studying; just as a cat or tiger presents us with a disposition in which, if brain-science is applicable, as it should be, to lower forms of life exhibiting special traits of character, destructiveness should be well represented and typically illustrated. Alas for phrenology! the bump of destructiveness in the feline races resolves itself into a mass of jaw muscles, and the elephant's brain is placed certainly not within a foot or so of the most skilful of phrenological digits. The "frontal sinuses" or great air-spaces in the forehead bones of the animal intervene between the front of the brain, the region *par excellence* of "intellect" and the outside layer of the skull. So that an observer could no more accurately construct a phrenological chart of an elephant than he could diagnose the contents of a warehouse by scanning the exterior of the building.

Not merely, however, are the difficulties of phrenology limited to the lower animals. Suppose we make a cross section of a human skull, through either the right or left side of the forehead, about half an inch above the upper border of the orbit or eye-cavity. We may then discover that man as well as the elephant possesses "frontal sinuses" or air-spaces in his forehead-bone of considerable extent, intervening between the exterior of the skull and the contained brain. Now, in such a section of the human skull, what phrenological "organs" shall we cut through? Certainly those of "individuality," "form," "size," "colour," and "calculation." In placing such organs across the eyebrows the phrenologist might naturally be regarded as having proceeded on the assumption that he was mapping out on the exterior of the skull a certain part of the brain-surface. What shall be said of his procedure, however, when the reader learns that a section of the skull made as indicated through these organs shows that they—*i.e.* the "organs" as marked on the outside of the skull—overlie the hollow spaces or "frontal sinuses," and are actually separated from the brain by cavities of considerable extent, in some cases exceeding an inch? Such a demonstration truly speaks for itself, and no less so does the anatomist's discovery that the "organ" of phrenologists known as "form" actually reposes in anything but a noble position on the cavity of the nose; that the organ of "calculation" is a solid bony (*orbital*) process; and that the size of the organ of "language" really depends upon the want of forward projection of the eye depending on the special development of a bony process on which the organ of sight rests, and which in any case has nothing whatever to do with the brain. Of language more anon; but enough has been said to show that a connection with the brain is not an in-

variable or apparently necessary condition for the construction of a phrenological "organ" of the mind—the fact that the brain is the organ of mind notwithstanding.

Speaking of the "bumps" of the forehead, Mr. Holden, in his classic work on "Human Osteology," remarks that they "are not prominent in children, because the tables of the skull do not begin to separate to any extent before puberty. From an examination of more than one hundred skulls, it appears that the absence of the external prominence, even in middle age, does not necessarily imply the absence of the sinus (or air-cavity existing between the two 'tables' of the bone), since it may be formed by a retrocession of the inner table of the skull. In old persons, as a rule, when the sinuses enlarge, it is by the inner table encroaching on the brain-case. The skull wall follows the shrinking brain. The range of the sinuses may extend even more than half-way up the forehead, and backwards for an inch or more along the orbital plate of the bone. Sometimes one sinus is larger than the other, and consequently the 'bump' on one side of the forehead may naturally be more prominent than that on the other. . . . In the Museum of the Royal College of Surgeons, there is an instructive collection of horizontal sections through the frontal bone at the level of the sinuses. In a specimen from a man æt. 32, it may be observed that though the sinuses are very extensive there is no external protuberance. In another from a man æt. 47, there are no sinuses, yet there is a great external protuberance. One obvious conclusion from all this is," says Mr. Holden, "that the 'bumps' on the forehead mapped out in this situation by phrenologists, under the heads of 'locality,' 'form,' 'time,' 'size,' &c., do not necessarily coincide with any convolutions of the brain."

But neither does the case for phrenology fare any better when it is tested by the results of the examination of crania belonging to persons whose family or personal history was well known, and whose characters, in respect of their thorough and stable formation, would therefore serve as a test of phrenological or any other system of mind-explanation. In the heyday of phrenological discussion, and in Edinburgh as the very focus and centre of the arguments *pro* and *con* the system of Gall and Spurzheim, a Mr. Stone, then President of the Royal Medical Society, read in 1829 a paper in which the results of a most laborious and conscientious series of observations on the crania of well-known persons were detailed. These results, as will presently be shown, were fatal to any ideas which might have been entertained regarding the authentic nature of the data on which phrenological observations were founded. Fifty skulls were selected for measurement from the famous collection of Sir William Hamilton, fifty others being taken from that of Dr. Spurzheim himself. In the case of the skulls of fifteen murderers, whose

crimes had been marked by unusual brutality and violence, and who might therefore be regarded as exemplifying cases in which the largeness of the "organ" of destructiveness might be lawfully postulated by a phrenologist, Mr. Stone demonstrated by careful measurement and comparison that each of the fifteen had the organ or surface of "destructiveness" *absolutely less* than the average of ordinary heads, whilst thirteen of these skulls possessed this organ *relatively less* when compared with the whole contents of the brain-pan. Nor was this all. Thirteen of these fifteen worthies possessed a larger organ of "benevolence" than the average, and their "conscientiousness" was also as a rule well-developed. Their brains were not markedly deficient in front of the ear—the region of the intellectual faculties according to the phrenologist—nor were they unusually developed behind the ear, where the animal faculties are supposed to reside.

No less instructive were the comparisons instituted between the faculties of Dr. David Gregory, once Professor of Mathematics in the University of Edinburgh, and Savilian Professor of Astronomy at Oxford, a friend and contemporary of Sir Isaac Newton. Professor Gregory's character was well known as that of an amiable, accomplished, intellectual man. In such a case the moral faculties would be expected to present high development, whilst the animal faculties and baser qualities would naturally be regarded as being but poorly represented. Mr. Stone's measurements, duly verified by independent observers, elicited the awkward fact that Dr. Gregory should, according to the phrenological interpretation of his cranium, have ranked in the criminal category, since his organ of "destructiveness" was found to exceed in size that of every murderer in the collection under discussion! In proportion to the general size and form of the brain, Dr. Gregory's "destructiveness" was larger than that of the notorious Burke, who was executed at Edinburgh for the cold-blooded murder of men, women, and children, whose bodies, along with his coadjutor Hare, he sold for purposes of anatomical inspection. Not to enumerate in detail the startling results which the fair and unbiassed examination of Dr. Gregory's cranium afforded, it may simply be mentioned that the Professor's "combativeness" was larger than that of any of the debased villains with whom his faculties were compared. Burke equalled him in "benevolence;" in "secretiveness" he excelled the noteworthy fifteen; his "acquisitiveness" exceeded that of Haggart and other noted thieves; his "causality"—the power of reasoning closely, and of tracing the relations between cause and effect, a faculty which as a mathematician he should have possessed largely developed—was less than that of the criminals; and his intellectual faculties at large were of less capacity than theirs, as his animal faculties were present in greater force.

No further illustration is required of the fact that, tested under exceptionally favourable circumstances, the deductions of phrenology are absolutely incorrect, not to say absurd. Nor is the case of the phrenologists bettered by their exercise of apologetics in face of the hard logic of the above and similar facts. Thurtell, with very large "benevolence" and with well-developed "veneration," yet committed an atrocious murder, and this without a special development of "destructiveness." "Nothing can justify the murder," said the phrenologists, but Thurtell imagined that he would "do a service to society by killing his friend" (where his benevolence?), "and hence his crime." Thus benevolence, by the exercise of phrenological apologetics, becomes an excuse for and an active cause of murder. Dr. Gregory's "destructiveness," said the phrenologists, was held in check by some other qualities—by which qualities it would be hard to say, seeing that, tested by phrenology, his whole mental and moral organisation was below that of the average murderer. So that we are to believe, in short, that "destructiveness," and the other base qualities of the Professor, being absolutely useless, must have been intended simply for show and not for use. Things, on this reasoning, truly are not what they seem; and phrenology thuswise cuts away from under itself its fundamental propositions, that its "organs" are the seats of faculties, and that their activity is proportional to their size.

But to proceed further would be to slay the slain. Thus much, indeed, we have said of the phrenology which still lingers in our midst, by way of contrast with the newer order of brain-interpretation which the advance of physiology has caused to arise amongst us. In the early days in which the battle of phrenology was fought and won as against the science of brain-pans, physiological experimentation upon the brain was an unknown and unworked source of information. In due time came Flourens, Magendie, Fritsch, Hitzig, and Ferrier, with their exact methods and results, enlarging the conceptions of the brain and its powers, and throwing here and there a ray of light upon the dark places and hidden corners in the domain of the physiology of mind. Hence our new "phrenology"—for the word itself is perfectly explicit as denoting a science of mind or brain—is gradually being built up from sure data and accurate experimentation; the results arrived at by one worker being tested by a host of fellow-experimenters ere his inferences become facts, and before they are allowed to form part and parcel of the scientific edifice. Let us briefly see what are the more prominent facts concerning the brain and its functions which recent science has elucidated.

No part of the brain has perhaps presented problems of such interesting character as the *cerebellum* or lesser brain which, as already

remarked, exists at the hinder and lower part of the head (see figs. 23 B, and 24 *cb*), and which moreover presents us with a structure differing from that of the cerebrum itself. Phrenologists located in the cerebellum the purely sensual or animal faculties. These faculties are conspicuously exhibited by frogs, which possess but the merest strip of cerebellum. "A man," as we remember hearing a phrenological lecturer say, "with a head bulging out behind, is going backwards in the world;" and there was indeed, as we shall see, a modicum of truth (although he knew and understood it not) in the lecturer's remark, since without the cerebellum we could probably proceed neither forwards nor backwards. We now know that the old phrenology of the cerebellum is utterly wrong and unfounded. The new phrenology has shown us that in cases of diseased animal appetites, which in our lunatic asylums are but too frequently represented, the cerebellum is not found to be affected—a result explained by the fact that the appetites referred to are indeed as much part of our "mental" constitution as is the exercise of benevolence or of any other mental faculty.

Furthermore, the new phrenology supplies positive evidence as to the true functions of the cerebellum. When it is removed from a pigeon, for instance, the animal retains its faculties. It will feed, it can see and hear, but is utterly unable to maintain its equilibrium. If thrown into the air, it flaps its wings in an erratic and aimless fashion. In one word, it cannot "co-ordinate" its movements—that is, it cannot so adjust the motions of one set of muscles, as to bring them into purposive harmony with another set or series. The cerebellum thus appears to be the great brain-centre whence are issued the commands and directions which harmonise the muscular actions and movements of our lives. Contrariwise, the true functions of the cerebellum are proved by experiments in which this part of the brain has been left intact whilst the cerebrum or true brain has been removed. A bird or higher animal in such a case will lose all power of volition; it will be deprived of sight, hearing, and other senses; it will die of hunger unless fed; it will exhibit no desire to move; and will, in short, present a condition utterly opposed to that seen when the cerebellum is removed and the true brain left intact. But with its cerebellum present, and *minus* its true brain, the bird or other animal can perfectly "co-ordinate" its movements. It will fly straight if thrown into the air, it will walk circumspectly enough if pushed forwards, and will exhibit in fact such perfect muscular control, despite its want of volition and intellect, that the functions of the cerebellum as a controller and co-ordinator of movements are no longer matter of hypothesis, but have become staple physiological facts.

As Professor Ferrier remarks ("Functions of the Brain," second

edition, 1886, p. 200):—"Every form of active muscular exertion necessitates the simultaneous co-operation of an immense assemblage of synergic movements throughout the body to secure steadiness and maintain the general equilibrium; and on the hypothesis that the cerebellum is the centre of these unconscious adjustments, we should expect the cerebellum to be developed in proportion to the variety and complexity of the motor activities of which the animal is capable. The facts of comparative anatomy and development are entirely in harmony with this hypothesis. In the reptilia and amphibia, whose movements are grovelling and sluggish, or of the simplest combination, the cerebellum is of the most rudimentary character; while in mammals it is richly laminated, and the lateral lobes highly developed in proportion to the motor capabilities represented in the motor zone of the cerebral hemispheres.

"If we compare the relative development of the cerebellum in the several orders of the same class of animals, we find it highest in those which have the most active and varied motor capacities, irrespective of the grade of organisation otherwise; and the cerebellum of the adult is, relatively to the cerebrum, much more highly developed than that of the new-born infant—a relation which evidently coincides with the growth and development of the muscular system."

If, however, the old phrenology has been displaced from the cerebellum by the new, no less important is it to note that, regarding the functions of the true brain, modern research has been equally successful in deposing the old ideas of the "organs" and their attendant faculties as exhibited on the phrenological charts and busts. Experimentation on the brain of higher animals, *quoad* the brain itself, is absolutely painless—contrary to popular notions and ideas. True there are certain parts of the brain (*e.g.* the medulla, fig. 23, M. O.) which are exceedingly delicate, and in which the point of a needle would inflict at once a fatal injury. But the brain-substance itself is utterly non-sensitive, as every hospital-surgeon can tell us. Persons may actually recover from serious injuries of the brain in which several ounces of brain-substance may have been lost, and recover with good effect, and in many cases without any perceptible alteration of their mental peculiarity.

The most notorious case of this kind is known as "the American Crow-bar case." A bar of iron, accidentally shot off from a blast, passed through the top of a young man's head at the left side of the forehead, having traversed the front part of the left hemisphere or side of the brain. The iron bar measured three feet in length, and weighed fourteen pounds. After the accident he felt no pain, and was able to walk without help in a few hours' time. The man made a good recovery, and for twelve years made a livelihood by exhibiting

himself in the United States, his skull being now preserved in the museum of Harvard University. This patient undoubtedly lost a relatively large portion of his brain-substance. At one fell swoop, there must have been a considerable destruction of phrenological organs. Yet he suffered from no apparent deprivation of intelligence; and few would dream of associating the drinking habits which finally beset him, with his accident and with his loss of brain-matter, or otherwise maintain that he was less rational before than after the accident. Trousseau has also placed on record a case in which a man who was shot in the head, had the front part of his brain traversed by a bullet, and who, nevertheless, showed little or no apparent alteration of bodily or mental action as the result of his injury. Thus the misfortunes of existence and the experimentation of the physiologist positively contradict the old phrenology. They assert that localisation of function does exist, it is true, but they also show that the "organs" of the phrenologist are mere theoretical nonentities, without a trace of substance to ensure their stability or real nature.

What amount of localisation, then, can be safely assumed to exist in the human brain as revealed by recent experimentation? It may be known to the generality of readers that the movements, acts, and probably ideas relating to one side of the body are regulated by the opposite side or hemisphere of the cerebrum. Thus, convulsions affecting one side of the body were shown by Dr. Hughlings Jackson to be caused by disease of the opposite side, and the idea of the duality of the brain's action followed in a natural sequence on the observation of facts like the preceding. As a general rule, it may be affirmed that brain-disease itself, or the ideas of natural existence, are so far localised that their perfect effects are only visible and appreciated when the same parts in both halves or hemispheres of the brain are affected. To illustrate what the new phrenology has to say regarding the localisation of the brain-functions, let us inquire firstly into the modes through which we obtain our knowledge of the brain and its work. There are two means of ascertaining the functions of the brain. Experiments may be performed on the living animal when the brain is electrically stimulated; while disease of the brain —nature's experimentation in fact—affords a second method of acquiring knowledge regarding the duties of different regions of the great nervous centres.

Proceeding by the first or experimental method, Professor Ferrier (to whom I am indebted for the use of figures from his work on "The Functions of the Brain") has been enabled to map out the surface of the cerebrum into definite areas. Thus in figs. 25 and 26 the cerebrum of the monkey is represented as mapped out into definite areas corresponding with ascertained functions performed by these regions. When the area marked 1 is stimulated, the animal

advances the opposite hind limb, as in walking. Stimulation of the region marked 2, gives complex movements of thigh, leg, and foot, as in grasping with the foot, or scratching the chest or abdomen with its foot; 3, movements of the tail, associated with the preceding actions; 4, retraction with extension and abduction of the opposite arm, the hand being pronated; 5, extension forwards of the opposite arm and hand as if to touch something in front; *a*, *b*, *c*, *d*, individual and combined movements of fingers and wrist ending in clenching the fist, and illustrated in prehensile movements of the opposite hand; 6, supination and flexion of the forearm, as in raising the hand to the mouth; 7, action of the zygomatic muscles, by which the angle of the mouth is retracted and elevated; 8, elevation of the sides of nose and upper lip, exposing the eye-teeth; 9 and 10, opening of the mouth with protrusion (9) and retraction (10) of the tongue; 11, retraction of opposite angle of the mouth; 12, wide opening of eyes, dilatation of pupils, and head and eyes turning to opposite side; 13 and 13′, movement of eyes towards opposite side, with upward or downward deviation; 14, pricking of opposite ear, head and eyes turning to opposite side and pupils dilating

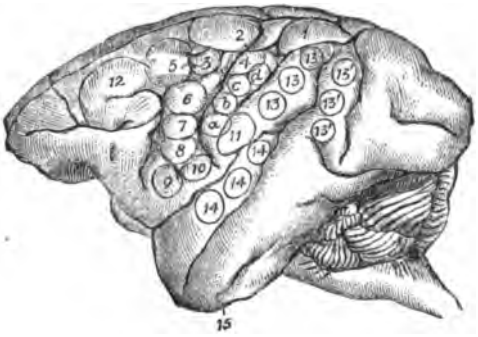

FIG. 25.—THE LEFT SIDE OF MONKEY'S BRAIN (Ferrier).

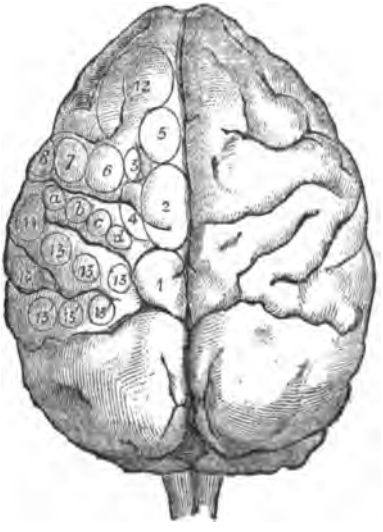

FIG. 26.—MONKEY'S BRAIN VIEWED FROM ABOVE.

widely ; 15, twisting of lip and nostril on the same side, causing partial closure of nostril, as when a pungent odour is applied.

In figs. 27 and 28, the similar areas have been applied to illustrate the functions of the human brain. Here, the results of brain-disease in man serve as means of verifying the conclusions which have been arrived at from experimentation on lower animals. The figures indicating the areas on the brain of the monkey, have a corresponding significance on the brain of man. By way of briefly

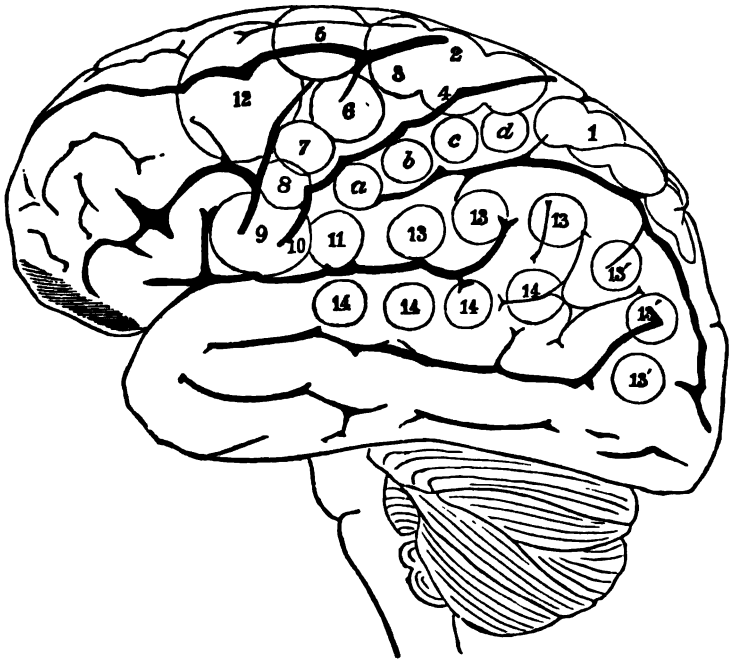

FIG. 27.—FERRIER'S CENTRES MAPPED OUT IN HUMAN BRAIN (Left Side).

testing the correctness of the physiologist's views, the history of one region may be noticed.

The regions 9 and 10 in the brain of the monkey are found to be associated with movements resulting in opening the mouth and with protrusion and retraction of the tongue. Now, in man, there is liable to occur a singular disease to which the name of *aphasia* or "speechlessness" has been given.

Persons affected with this lesion understand perfectly what is said

to them, but they are absolutely speechless, and cannot utter a single word. It is a perfectly well-ascertained fact that aphasia, as a rule, is associated with disease of Brocas' convolution, the front part of the *left* half or hemisphere of the brain—a part which may therefore be called the "speech centre," and which is figured 9 and 10 in the illustrations of man's brain (figs. 27 and 28). The curious fact must thus be emphasised, that aphasia is almost invariably associated with disease of the *left* (9 and 10), and rarely with disease of the right side

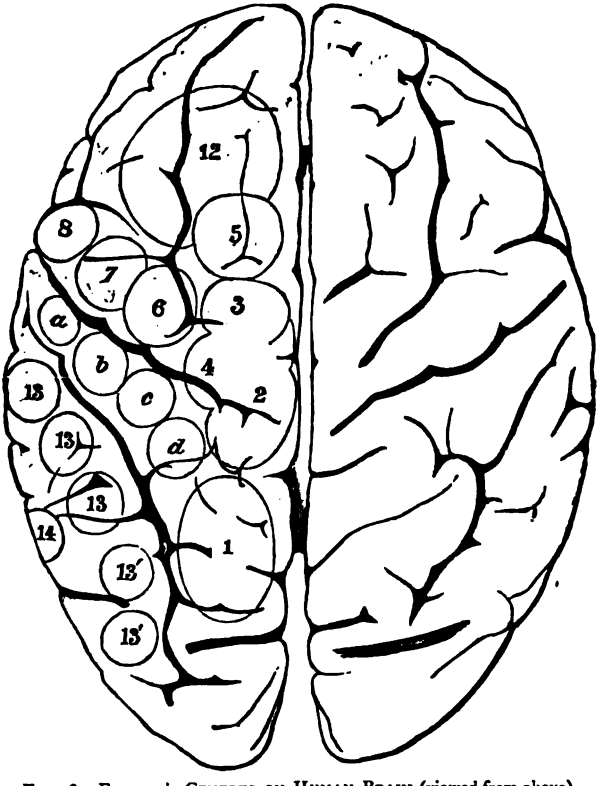

FIG. 28.—FERRIER'S CENTRES ON HUMAN BRAIN (viewed from above).

of the brain. It is a noteworthy fact in brain-physiology, that when an animal has been rendered blind by the destruction of the sight-centre of one side, blindness disappears and sight gradually returns, since the remaining and normal sight-centre of the opposite side

assumes the functions of its neighbour. Complete blindness only ensues when both sight-centres are diseased. The same remark holds good of the movements of the mouth and tongue in speech, these being "bilateral," so that the centre of these latter movements on one side may be destroyed without causing paralysis of the tongue, provided the centre of the other side is uninjured. Movements of the hands and feet are, on the contrary, one-sided. Destruction of one centre governing these latter movements, ensures complete cessation of the movements on the opposite side of the body.

Now, in aphasia or speechlessness, we merely perceive the results of the destruction of the single speech-centre—the left—which man normally uses to express his thoughts. Just as we use the right hand in preference to the left in prehension, in writing, and in performing all the delicate operations of our lives, and just as the movements of the right hand are regulated by the left side of the brain, so our faculty of articulation is also unilateral and single-handed, so to speak. The memory of sounds and words forms the basis of our speech—"the memory of words is only the memory of certain articulations"—and those parts of the brain which regulate articulation are also the memory-centres for speech or the result of articulation. Thus, when the speech-centre is disorganised, not merely the power of articulation disappears, but also the memory of words.

But whilst the left side is that of the speech-centre, there is no reason, as Dr. Ferrier remarks, apart from heredity and education, why this should necessarily be so. "It is quite conceivable," Dr. Ferrier holds, "that a person who has become aphasic by reason of total and permanent destruction of the left speech-centre, may reacquire the faculty of speech by education of the right articulatory centres." We speak with the left side of our brains, in short, not because we are unable to do so with the right side, but simply because habit and the law of likeness together strengthen and perpetuate the custom of speaking with the left. But it may be also supposed, that as a left-handed person must regulate the movements of his arms chiefly by the right side of his brain, so there may exist subjects who naturally use the right instead of the left speech-centre.

Dr. Ferrier on this point remarks that "a person who has lost the use of his right hand may, by education and practice, acquire with his left all the cunning of his right. In such a case, the manual motor centres of the right hemisphere become the centres of motor acquisitions similar to those of the left. As regards the articulating centres, the rule seems to be that they are educated, and become the organic seat of volitional acquisitions on the same side as the manual (and left) centres. Hence, as most people are right-handed, the education of the centres of volitional movements takes place in the left hemisphere. This is borne out by the occurrence of cases of aphasia with

left hemiplegia (*i.e.* paralysis on the left side) in left-handed people. Several cases of this kind have now been put on record. These cases," continues Professor Ferrier, "more than counterbalance any exception to the rule that the articulating centres are educated on the same side as the manual motor centres. The rule need not be regarded as absolute, and we may admit exceptions without invalidating a single conclusion respecting the pathology of aphasia as above laid down. An interesting case has been reported by Wadham ('St. George's Hospital Reports,' vol. iv.) of aphasia with left hemiplegia occurring in a young man belonging to a family of *gauchers*; yet this person had learnt to write with his right hand, so that as regards speech he was right-brained, but as regards writing he was left-brained."

The person who suffers from aphasia, it may be added, still remains capable of understanding what is said to him, because his sight, hearing, and other senses, as well as his intelligence, are intact. The meaning of the sounds he hears is understood, although there is inability to call up words in response. It is usual to find the aphasic person also unable to write words by way of expressing his thoughts. He then suffers from *agraphia* as well as *aphasia*, and this result is explicable simply on the ground of the close connection which exists between vocal speech and written speech. "By education," says Dr. Ferrier, "and by the familiarity engendered of long practice in expressing ideas by written symbols, a direct association becomes established between sounds and ideas and symbolic manual movements without the intermediation of articulation; and in proportion as the translation through articulation is dispensed with, in that proportion will an individual continue able to write who is aphasic from disease of his speech-centre."

In this fashion, then, we see how the facts of the new phrenology supersede the childish deductions of the old. We note how the exact experimentation of science serves to dispel the myth with which the phrenologist once surrounded the question of mind-localisation. In place of language—itself an ill-defined term—being situated in the eye-region, as the phrenologist has placed it, we find the speech-centre to be situated in Brocas' convolution on the third left frontal lobe. We see in the frontal or forehead lobes of the brain the regions which exercise the highest intellectuality, and which are the seat of "mind," properly so called. The other parts of the cerebrum we discover are devoted to the control of movements of various kinds, which represent the results of the exercise of the mind and will. It is in this fashion that science slays the old phrenological systems, and replaces them by the definite knowledge which, founded upon experiment and observation of man and animals, raises a superstructure of fact upon a secure basis, capable of being further tried and tested by the research of the future.

Whatever results may in future accrue to human knowledge from researches into the functions of the brain, no one may doubt the all-important nature of the knowledge which literally enables man to know himself, and to understand in some degree the mainsprings of the actions which constitute his daily existence. The subject is no less instructive in the sense in which it shows the displacement of erroneous ideas by new and higher thoughts founded on accurate observation of the facts of life. In a very direct fashion, also, such higher knowledge may affect suffering humanity; since an educated medical science, furnished with secure data regarding the causes of mental affections, may successfully "minister to minds diseased," and even in due time raze out the troubles which perplex many a weary soul.[1]

[1] It is interesting to note that as these sheets are passing through the press, cases of surgical interference with the brain for the removal of tumours are being, day by day, successfully recorded. A patient suffering severely from such brain lesion is now capable of being cured completely, by the surgical art which is founded on experimentation on living animals, discovering for us the true functions of the brain. Such triumphs, in literally snatching hopeless cases of brain-disease from acute suffering and death, form the best arguments against the ravings of anti-vivisectionists, whose chief contention has always been that experiment on living animals could be of no benefit to man.

XII.

THE MIND'S MIRROR.

In very varied fashions has philosophy endeavoured at various stages of its career to solve the problem of the face as the mind's mirror, and to gain some clue thereby to the ways and workings of the brain. Often when philosophy was at its worst and vainest, has the problem appeared most certain of solution. From classic ages, onwards to the days of Lavater, Gall and Spurzheim, the wise and occult have regarded their systems of mind-localisation as adapted to answer perfectly all the conditions whereby an enquiring race could test their deductions. But as time passed and knowledge advanced, system after system of mind-philosophy has gone by the board, and has been consigned to the limbo of the extinct and non-existent. Now and then the shreds and patches of former years are sought out by the curious to illustrate by comparison the higher and better knowledge of to-day; and occasionally one may trace in the bypaths of latter-day philosophies, details which figured prominently as the sum and substance of forgotten systems and theories of matter and of mind. So that the student of the rise and decline of philosophies learns to recognise the transient in science as that which is rapidly lost and embodied in succeeding knowledge, and the permanent as that which through all succeeding time remains stamped by its own and original individuality.

Especially do such remarks apply to the arts which have been employed to find "the mind's construction" in face or head. If Lavater's name and his long list of "temperaments" are things of the far-back past in science, no less dim are the outlines of the extinct science of brain-pans, over which Gall and Spurzheim laboured so long and lovingly, but for the name of which the modern student looks in vain in the index of physiological works dealing with the subjects "phrenology" once called its own. Pursued together in out-of-the-way holes and corners, the systems of Lavater and Gall are represented amongst us to-day chiefly by devotees whose acquaintance with the anatomy and physiology of the brain is not that of the scientific lecture-room, but that of the philosophers who deal in busts, and to whom a cranium represents an object only to be measured and mapped out into square inches of this quality and half-inches of that. Neglected because of their resting on no scientific basis, the doctrines of phrenology and physiognomy have died as

peacefully as the "lunar hoax" or the opposition to the theory of gravitation. The occasionally prominent revival of their tenets in some quarters, but represents the feeble scintillations which attend the decay and announce the transient survivals of movements whose days are numbered as parts of philosophical systems.

Whatever reasonable deductions and solid advances regarding the functions of brain and mind either "science" tended to evolve, have been long ago incorporated with the swelling tide of knowledge. Phrenology has vanished in the general advance of research regarding the functions of the brain; a region which, apparently without a cloud in the eyes of the confident phrenologist, is even yet unpenetrated in many of its parts by the light of recent experiment and past discoveries. Similarly the science of physiognomy has its modern outcome in the cant phrases and common knowledge with which we mark the face as the index to the emotions, and through which we learn to read the broader phases of the mind's construction. But the knowledge of the face—

> as a book
> Where men may read strange matters,

has been more fortunate than the science of brain-pans, in respect of its recent revival under new aspects and great authority. From Eusthenes, who "judged men by their features," to Lavater himself, the face was viewed as the mask which hid the mind, but which, as a general rule, corresponded also to the varying moods of that mind, and related itself, as Lavater held, to the general conformation and temperament of the whole body. So that the acute observer might be supposed to detect the general character of the individual by the conformation of the facial lineaments—crediting a balance of goodness here or a soul of evil there, or sometimes placing his verdict in Colley Cibber's words, "That same face of yours looks like the title-page to a whole volume of roguery." It argues powerfully in favour of the greater reasonableness of the science of faces, over its neighbour-science of crania, that we find even the vestiges of its substance enduring amongst us still. Of late years the face and its changes have become anew the subject of scientific study, although in a different aspect from that under which Lavater and his compeers regarded it. Now, the physiognomy is viewed, not so much in the light of what it is, as of how it came to assume its present features. Facial movements and "gestic lore" are studied to-day in the light of what they once were, and of their development and progress. Admitting, with Churchill, the broad fact that the face—

> by nature's made
> An index to the soul,

modern science attempts to show how that index came to be compiled. In a word, we endeavour, through our modern study of

physiognomy, to account for how the face came to be the veritable "Dyall of the Affections" which the science of yesterday and that of to-day agree in stamping it.

Regarding the face as the chief centre wherein the emotions and feelings which constitute so much of the individual character are localised, common observation shows us, however, that the mind's index is not limited to the play of features alone. A shrug of the shoulders may speak as eloquently of disdain as the stereotyped curl of the upper lip and nose. The "attitude" of fear is as expressive as the scared look. The outstretched and extended palms of horror are not less typical than the widely opened eyes and the unclosed lips. Gesture language—the speech of the bodily muscles—is in truth almost as much a part of our habitual method of expression as the muscular play of the face; and the emotions displayed by the countenance gain immeasurably in intensity when aided by the appropriate gestures which we have come tacitly to recognise as part and parcel of our waking lives. No better portrait of the part which muscular movements play in the enforcement of language and feelings has been drawn than that of Shakespeare's Wolsey. Here the picture teems with acts of gesture, each eloquent in its way, and testifying to the conflicting passions and emotions which surged through the busy brain of Henry's counsellor:—

> Some strange commotion
> Is in his brain; he bites his lip and starts;
> Stops on a sudden, looks upon the ground,
> Then lays his finger on his temple; straight,
> Springs out into fast gait; then stops again,
> Strikes his breast hard; and anon, he casts
> His eye against the moon: in most strange postures
> We have seen him set himself.

We thus obtain, from the full consideration of the means which exist for the expression of the emotions, the knowledge that not the face alone, but the common movements of body and limbs, have to be taken into account in the new science of emotional expression which has thus arisen amongst us. Properly speaking, the modern physiognomy is one of the body as a whole, and not of face alone; and above all, it is well to bear in mind that the newer aspect of the science deals not merely and casually with this gesture or that, but with the deeper problem of how the gesture came to acquire its meaning and how the "strange postures" of face and form were evolved.

By way of fit preface to such a subject as the expression of the emotions in a scientific sense, we may, firstly, glance at the emotions themselves and at their general relations to the bodily and mental mechanism of which they form the outward sign and symbol. It is well that, primarily, we should entertain some clear idea as to the exact place which the emotions occupy in the list of,

mental phases and states. Leaving metaphysical definitions as but little fitted to elucidate and aid a popular study, we may feasibly enough define an "emotion" as consisting of the particular changes which peculiar states of mind produce upon the mind and body. Such a definition, simple though it appear to be, really extends as far as any mere definition can in the endeavour to present a broad idea of what "emotions" imply and mean. By some authors, the "emotion" is interpreted as the mental state which gives rise to the bodily disturbance. But such a mode of treating the term is simply equivalent to an attempt to define the shadow and ignore the substance. Says Dr. Tuke, whose authority in all matters relative to the relation betwixt mind and body we must gratefully acknowledge, "Every one is conscious of a difference between a purely intellectual operation of the mind and that state of feeling or sentiment which, also internal and mental, is equally removed from (though generally involving) a bodily sensation, whether of pleasure or pain; and which, from its occasioning suffering, is often termed Passion; which likewise, because it moves our very depths, now with delight, now with anguish, is expressively called Emotion—a true commotion of the mind, and not of the mind only, but of the body." And in a footnote, Dr. Tuke is careful to remind us that "it is very certain, however, that our notion of what constitutes an emotion is largely derived from its physical accompaniments, both subjective and objective." That is to say, the nature of the mental act—which is by some authors exclusively named the emotion—may be, and generally is, imperfectly understood by us; and the name is given rather to the obvious effects of the mind's action on the face and body, than to the mental action which is the cause of these visible effects. Such a result is but to be looked for so long as the mental acts are contained and performed within a veritable arcanum of modern science. The emotion renders us conscious "subjectively," or within ourselves, of the mental states which cause the outward postures of body or phases of face. "The modern student," says Mr. Fiske, in a charming volume,[1] "has learned that consciousness has a background as well as a foreground, that a number of mental processes go on within us of which we cannot always render a full and satisfactory account." And whilst the source of the common emotions of everyday life is no doubt to be found in the ordinary sensations which originate from our contact with the outer world, there are other emotions which arise from the "background of consciousness," and which are manifested in us as actively and typically as are the common feelings of the hour which we can plainly enough account for.

To descend from theory to example in this case is an easy task. The blush which has been called into the cheek by a remark made

[1] *Darwinism and other Essays.*

in our hearing, is as fair and simple an illustration of the objective source of emotions as could well be found. The production of the emotion in such a case depends upon the ordinary laws of sensation, through the operation of which we gain our knowledge of the world —nay, of ourselves also. Waves of sound set in vibration by the voice of the speaker, have impinged upon the drum of the ear. Thence converted into a nervous impression or impulse, the sound-waves have travelled along the auditory nerve to the brain. There received as a "sensation"—there appreciated and transformed into "consciousness"—the brain has shown its appreciation of the knowledge conveyed to it by the ear, in the production through the nerve-mechanism of the bloodvessels, of the suffused tint which soon overspreads the face. But this direct production of an emotion by mental action, and from the foreground of consciousness, is opposed in a manner by a second method which may be termed "subjective" by way of distinction from the objective sensation derived from the voice of the speaker, and giving rise to the blush. From the "background of consciousness," wherein Memory may be said to dwell, there may come the remembrance of the occasion which gives rise directly to the blush. Projected into the foreground of consciousness, the subjective sensation may be as vividly present with us in the spirit as when it was felt in the flesh. True to its wonted action, the brain may automatically influence the heart's action, and suffuse the countenance as thoroughly as if the original remark had that moment been made. Ringing in the ears of memory, the subjective sensation may be as powerful as when it was first received from the objective side of life.

As has well been remarked, the import and effects of subjective sensations may not be lightly estimated in the production of various phases of the mental life. "When an exceedingly painful event produces great sorrow, or a critical event great agitation, or an uncertain event great apprehension and anxiety, the mind is undergoing a passion or suffering; there is not an equilibrium between the internal state and the external circumstances; and until the mind is able to reach adequately, either in consequence of a fortunate lessening of the outward pressure, or by a recruiting of its own internal forces, the passion must continue; in other words, the wear and tear of nervous element must go on. Painful emotion is in truth *psychical pain*: and pain here, as elsewhere, is the outcry of suffering organic element—a prayer for deliverance and rest." And again, this author —Dr. Maudsley—speaking of the *rationale* of emotion, which in its graver exhibition may produce derangement of mind, says: "When any great passion causes all the physical and moral troubles which it will cause, what I conceive to happen is, that a physical impression made upon the sense of sight or of hearing is propagated along a physical path (namely, a nerve) to the brain, and arouses a physical

commotion in its molecules; that from this centre of commotion the liberated energy is propagated by physical paths to other parts of the brain, and that it is finally discharged outwardly through proper physical paths, either in movements or in modifications of secretion or nutrition (*e.g.* the influencing of heart and bloodvessels as in blushing). The passion that is felt is the subjective side of the cerebral commotion—its *motion* out from the physical basis, as it were (*e-motion*), into consciousness—and it is only felt as it is felt by virtue of the constitution of the cerebral centres, into which have been wrought the social sympathies of successive ages of men; inheriting the accumulated results of the experiences of countless generations, the centres manifest the kind of function which is embodied in their structure. The molecular commotion of the structure is the liberation of the function; if forefathers have habitually felt, and thought, and done unwisely, the structure will be unstable and its function irregular." So much for the nature of emotion, for the connection of the emotions with sensation, and for the part which the feelings may play in inducing aberration of mind. In the concluding words of the paragraph just quoted lies the explanation of the production of mind-derangements through an hereditary bias, namely, the perpetuated effects of ill-regulated mental acts. In the same idea, that of continued and transmitted habit, exists the key to the understanding of the origin of emotions. Above all other causes, habit has acted with extreme power and effect in inducing the association not merely of groups of actions expressive of emotions, but also in forming and stereotyping trains of thought and ideas in harmony therewith. On some such plain consideration, the real understanding of many problems of mind may be said to rest; and certainly in the subject before us it is one we cannot afford to lose sight of throughout the brief study in which we are engaged.

Any such study, however limited its range, must devote a few details to the question concerning the seat of the emotions in the chief centre of the nervous system. Of old, the peculiar system of nerves lying along the front of the spine, and called the "sympathetic system," was believed to possess the function of bringing one part of the body into relation with another part. To this system in modern physiology is assigned the chief command of those processes which constitute the "organic life" of higher animals, and which, including such functions as digestion, circulation, &c., proceed under normal circumstances independently of the direct operation of will and mind. Liable to be influenced and modified in many ways by the will and by the nervous acts which compose the waking existence of man, the sympathetic nerves may nevertheless be regarded as the chief and unconscious regulators of those processes on the due performance of which the continuity and safety of life depends. But in the physio-

logy of past days these nerves were credited with the possession of a much more intimate relation to the play of emotions. By some authorities in a past decade of science, the seat of the emotions was referred exclusively to the nerves in question and to the processes which they regulate. Under the influence of these nerves and of the emotions, argued these theorists, we see the functions of the body gravely affected; and in some "epigastric centre," as the chief nerve-mass of this system was termed, the emotions were declared to reside. But in such a theory of the emotions, results were simply mistaken for causes. On the ground that disturbance of the heart's action, or of digestion, occurred as a sign and symptom of emotion, the play of feelings was assigned to the bodily organs, whither in classic ages had been set the "passions" and "humours" residing in spleen, liver, and elsewhere.

But in modern science *nous avons changé tout cela*. If we are not thoroughly agreed as to the exact location of the emotions in the brain itself, we at least by common consent regard the central organ of the nervous system as the seat of the feelings which play in divers ways upon the bodily mechanism. Most readers are conversant with the fact that all brains, from those of fishes to those of quadrupeds and man, are built up on one and the same broad type; exhibiting here and there, as we ascend in the scale, greater developments of parts which in lower life were either but feebly developed or otherwise unrepresented at all. To this plain fact, we may add two others which lead towards the understanding of the seat and *locale* of the emotions. In man and his nearest allies, two of the five or six parts of which a typical brain may be said to consist have become immensely developed as compared with the other regions. And it is on this latter account that we familiarly speak of man's brain as consisting of two chief portions—the big brain, or *cerebrum*, filling well-nigh the whole brain-case; and the little brain, or *cerebellum*, which lies towards the hinder part of the head. To these chief parts of the brain we may add—by way of comprehending the emotional localities—the "sensory ganglia," or, as they are collectively termed, the "sensorium." In these latter nerve-masses or ganglia the nerves of special sense—those of sight, hearing, smell, &c.—terminate. Impressions of sight, for instance, received by the eyes, are transferred to the appropriate ganglia in which the act of mind we term "seeing" is excited. And so also with hearing and the other senses; the organ of sense being merely the "gateway of knowledge," and the true consciousness in which knowledge resides being thus excited within the brain. Add to these primary details one fact more, namely, that the spinal cord, protected within the safe encasement formed by the backbone, possesses at its upper or brain end a large nervous mass known as the "medulla ob-

longata," and our anatomical details respecting the nerve-centres may be safely concluded. From the "medulla oblongata" the nerves which in large measure regulate or affect breathing, swallowing, and the heart's action, spring; so that whatever be the importance of the "medulla oblongata" as an independent centre of mind or brain, there can be no question of its high office as a controller of processes on which the very continuance of life itself depends.

In what part of the nerve-centres are the emotions situated—in big brain, little brain, sensorium, or medulla?—is a query which may now be relevantly asked. The ingenuous reader, imbued with a blind faith in the unity of scientific opinion on matters of importance, will be surprised to find that in the archives of physiology very varied replies may be afforded to this question. Opinions backed by the weight of great authority will tell us that "big brain" is the seat of the emotions, intelligence, the will, and of all those higher nerve functions which contribute to form the characteristic mental existence of man. Such a view, say its upholders, is supported more generally and fully by the facts of physiology and zoology, and by those of sanity and insanity, than any other theory of the exact situation of the "mental light." Authority of equally eminent character, however, is opposed to the foregoing view regarding the superiority of the big brain over all other parts of the nervous centres; and in this latter instance our attention is directed to the claims of the "sensorium" as already defined, and as distinguished from the big brain itself, to represent the seat of the emotions.

The emotions of the lower animals, we are reminded, bear a relation to the development of these sensory ganglia, rather than to that of the big brain. Dr. Carpenter, for instance, insists that "it is the *sensorium*, not the cerebrum, with which the will is in most direct relation." Big brain, in the opinion of Carpenter, "is not essential to consciousness;" it is insensible itself to stimuli—that is to say, the brain itself has no sensation or feeling—and it further "is *not* the part of the brain which ministers to what may be called the 'outer life' of the animal, but is the instrument exclusively of its 'inner life.'" Impressions of sight are received by the sensory ganglia or masses in relation with the eye; and, adds Carpenter, it would seem probable that *consciousness* of sight only happens when the impression sent from the sensory ganglia to the big brain has returned to these ganglia, and has *reacted* upon these latter as the centres of sight. Thus, according to Dr. Carpenter's theory, we may hold the sensorium to be the true seat of the emotions. Inasmuch as we only become conscious of a sight-impression when it has been transmitted back to the sensory ganglia from the big brain, in like manner we become cognisant of an emotion only when the impression has been returned to the sensorium after being modified in the big brain. The latter supplies the modify-

ing effects, but it is left for the sensory masses of the brain to excite consciousness and to further distribute the emotions through the body. By way of fortifying his position, Dr. Carpenter gives the following case quoted from Dr. Abercrombie's "Intellectual Powers":—"In the Church of St. Peter at Cologne, the altarpiece is a large and valuable picture by Rubens, representing the martyrdom of the Apostle. This picture having been carried away by the French in 1805, to the great regret of the inhabitants, a painter of that city undertook to make a copy of it from recollection; and succeeded in doing so in such a manner, that the most delicate tints of the original are preserved with the most minute accuracy. The original painting has now been restored, but the copy is preserved along with it; and even when they are rigidly compared, it is scarcely possible to distinguish the one from the other." Dr. Abercrombie also relates that Niebuhr, the celebrated Danish traveller, when old, blind, and infirm, used to describe to his friends, with marvellous exactitude, the scenes amidst which he had passed his early days, remarking "that as he lay in bed, all visible objects shut out, the pictures of what he had seen in the past continually floated before his mind's eye, so that it was no wonder he could speak of them as if he had seen them yesterday." Thus, urges Dr. Carpenter, these instances, equally with Hamlet's declaration that he beholds his father in his "mind's eye," are only to be explained as ideational or internal representations of objects once seen. The "background of consciousness" has projected them forwards, in other words, into the waking life in the form of subjective sensations.

The same "sensorial state" must have been produced in the case of the painter and in that of Niebuhr as was produced by the original objects each had gazed upon—"that state of the sensorium," says Carpenter, "which was *originally* excited by impressions conveyed to it by the nerves of the *external* senses, being *reproduced* by impressions brought down to it from the cerebrum (or big brain) by the nerves of the *internal* senses." Lastly, it may be added that by a third section of the physiological world the *medulla oblongata*, or in other words the upper segment of the spinal cord, is to be regarded as the seat of the feelings. The late Professor Laycock inclined strongly towards this latter opinion. He held that the changes connected with the receipt and transmission of impressions from the outside world finally ended in the medulla, and there resulted in the development of the higher feelings and sentiments; whilst ordinary and automatically adapted movements might take place entirely unaccompanied by sensation or consciousness. The medulla in this view is the seat "of all those corporeal actions—cries and facial movements—by which states of consciousness are manifested," and these movements "can be and are manifested automatically." Mr.

Herbert Spencer's views refer "all feelings to this same centre, admitting also the co-operation of the other parts of the brain. By itself, the medulla cannot generate emotion," but, adds Mr. Spencer, "it is that out of which emotion is evolved by the co-ordinating actions of the great centres above it." How, by way of conclusion, can we account for the diversity of views thus expressed, and to which side should we lean in our views regarding the seat of the emotions? Probably, as a tentative measure, we may rest most safely by assuming that the production of emotion is a compound act in which not merely the big brain but the sensorium is likewise concerned, as implied by Dr. Carpenter; and further, that through the medulla the effects of the emotions—or the emotions as we behold them in the body—are ultimately evolved. "Much may be said on both sides" of the argument, to use Sir Roger de Coverley's phrase. The difficulty has nowhere been more fairly summarised than in Dr. Tuke's declaration that "there are objections to the attempt to dissever and separately localise the intellectual and the emotional elements, mental states in which they are combined; and yet I cannot but think that such a special relationship between the emotional element and the medulla must be admitted, as shall explain why the passions act upon the muscles and upon the organic functions in a way universally felt to be different from that in which a purely intellectual process acts upon them. On the hypothesis which refers the emotional and intellectual elements equally to the hemispheres (big brain), or which does not at least recognise that the power of expressing emotions is dependent upon the medulla oblongata, it seems to me more difficult to account physiologically for the popular belief of the feelings being located in the heart or breast, and for the sensations at the pit of the stomach; while the recognition, in some form or other, of an anatomical or physiological connection between the medulla oblongata and the emotions, brings the latter into close relation with the ganglionic cells of the pneumogastric (a nerve in part controlling the movements of the heart, of breathing, and swallowing) and with the alleged origin of the sympathetic."

Thus far we have been engaged in the study of the physiology of the emotions, and in the endeavour to comprehend the nature of the feelings from the nervous side. Our next duty lies in the direction of endeavouring to understand the development of the outward signs of the emotions as displayed not merely in the mind's mirror—the face itself—but in the body at large also. As the emotions are expressed through muscular movements of various kinds—blushing itself being no exception to this rule—our first inquiries may be directed towards ascertaining the exact nature of the relationship between mind and muscle. The ultimate question which awaits solution will resolve itself into the query, "How has this relationship

been developed and perfected?" The emotion, as we have seen, may be said to include in its production the outward and visible expression of an idea, and in this light emotional movements not merely express each its particular thought, but correspond to the well-defined mental state which gave origin to the thought. Emotional movements in others are thus capable of exciting similar and corresponding thoughts in ourselves. Nay, even words and language fall into their definite place in the expression of the emotions, simply when viewed as corresponding to ideas. "Speak the word," says Dr. Maudsley, "and the idea of which it is the expression is aroused, though it was not in the mind previously; or put other muscles than those of speech into an attitude which is the normal expression of a certain mental state, and the latter is excited."

Turning to the emotions, we see the marked correspondence between ideas and muscular expressions. Language expresses our meaning through "audible muscular expression;" and through "visible muscular expression" the passions hold their outward sway. Bacon's idea of the importance of the study of the expression of the emotions is well known—"the lineaments of the body do disclose the disposition and inclination of the mind in general: but the motion of the countenance and parts do not only so, but do further disclose the present humour and state of the mind or will." It is no mystery, but the plainest of inferences, that the play of prominent and oft-repeated emotions may thus come to determine a special configuration of face, which may reappear in after generations in the "types" to which Lavater and his contemporaries directed so much attention.

> For evil passions, cherish'd long,
> Had plough'd them with impressions strong,

says Sir Walter Scott, in describing the features of Bertram; and the poet in such a case but repeats in æsthetic phrase the plain inferences and facts of the science of life.

The muscular acts involved in the production of the most common emotions are not difficult to comprehend, and merely involve an easy anatomical study. My friend Professor Cleland of Glasgow has in a recent paper given an excellent example of this mechanism, and has incidentally shown how attitudes and gestures of body express correlated workings of mind. In the expression of movements of receiving and rejecting—of welcome and repulse—the chief muscles are concerned. The *pectoralis major*, or chief muscle of each side of the breast, is chiefly concerned in the act of embrace and welcome; a second (the *latissimus dorsi*) being employed in the act of rejection—this latter muscle might in fact, as Dr. Cleland remarks, "be called the muscle of rejection," a name which would express its action more accurately as well as more becomingly than that

given to it by old anatomists. The two conditions of muscle—contraction and relaxation—under varying circumstances and combinations in different groups of muscles, may be held to be capable of expressing the entire play of human feelings. The explanation of the mechanism of expression consists merely in a knowledge—not as yet possessed by us in perfect fashion—of the various relations which may persist at one and the same moment between separate muscles in a given region, or between groups of these muscles. Look at an anatomical plate—such as may be found in Sir Charles Bell's "Anatomy of Expression," enhanced for our present purpose by the addition of a text which has become of classic nature—and mark off therein the eyebrow muscles, called the *orbicularis palpebrarum* (19) and *pyramidalis nasi* (1). When we speak of the lowering expression foreboding rage and anger, the lineaments are placed in the expressive phrase just indicated, by the contraction of the muscles in question. It is the *occipito-frontalis* muscle (20, 27, 32) which contracts in the peering look of inquisitiveness or in the hopeful aspect of joy. And when the space betwixt the eyebrows becomes wrinkled, as in the frown of displeasure or in the act of solving a knotty problem, it is the *corrugator* (26) which produces the well-known sign of the mind's trouble. The "grief muscles" of Mr. Darwin are the orbiculars, corrugators, and pyramidals of the nose, which act together so as to lower and contract the eyebrows, and which are partially checked in their action by the more powerful action of the central parts of the

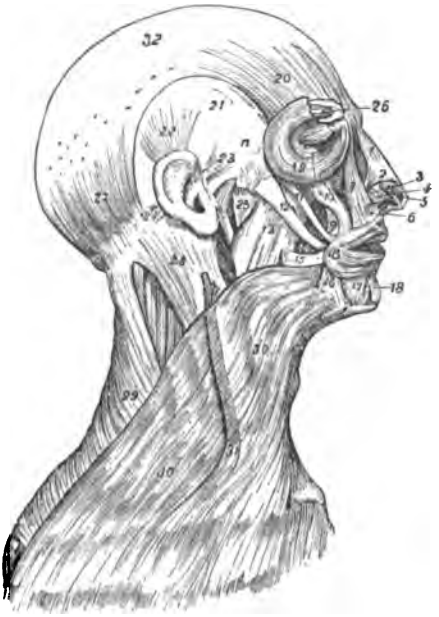

FIG. 29.—MUSCLES OF HEAD, FACE AND NECK (Gray).

1, Pyramidalis nasi; 2, Compressor naris; 3, 4, 5, dilators and compressors of the nose; 6, depressor alæ nasi; 7, levator labii superioris et alæ nasi; 8, orbicularis oris; 9, levator anguli oris; 10, levator labii superioris; 11, 12, zygomatici; 13, masseter; 14, buccinator; 15, risorius; 16, depressor anguli oris; 17, depressor labii inferioris; 18, levator menti; 19, orbicularis palpebrarum; 20, 27, 32, occipito-frontalis; 21, temporal fascia; 22, atollens aurem; 23, 24, attrahens and retrahens aurem; 25, deep part of masseter; 26, corrugator; 28, sterno-mastoid; 29, trapezius; 30, platysma; 31, external jugular vein.

frontal muscles. These muscles induce an oblique position of the eyebrows, characteristic of grief, and associated with a depression of the corners of the mouth. So, also, we witness correlated muscular action in that most characteristic of expressions, whether seen in man or in lower animals, the action of snarling or defiance, wherein the canine or eye tooth is uncovered by the angle or corner of the mouth being "drawn a little backwards, and at the same time a muscle (7) which runs parallel to and near the nose draws up the outer part of the upper lip, and exposes the canine tooth, as in sneering, on this side of the face. The contraction of this muscle," adds Mr. Darwin, "makes a distinct furrow on the cheek, and produces strong wrinkles under the eye, especially at its inner corner." The *orbicularis palpebrarum* (19) above mentioned closes the eyelids in sleep, and in the act of winking it is the upper fibres of this muscle which alone act. On the other hand, in executing the "knowing wink," when the lower eyelid comes into play, the lower fibres of this muscle are put in action. The distension of the nostrils (seen equally well in an overdriven horse and in an offended man) is effected by *levator* and other muscles, whilst one of these muscles (7), sending a little slip down to the upper lip, aids us, as just mentioned, in giving labial expression to a sneer.

The mouth, like the eye, is encircled by the fibres of a special muscle (18) (the *orbicularis oris*), which closes the mouth and presses the lips against the teeth, and this expresses the idea of "firm set determination." The mouth is opened by other muscles (*levators* and *depressors* of the lips) (7, 10, 16, 17), and it is transversely widened by the *zygomatic* muscles (11, 12) and by the *risorius* muscles (15), which latter derive their name from the part they play in the expression of laughter. It is interesting, lastly, to note that in man's muscular system we find the remains and rudiments of many muscles of the utmost importance to, and which have a high development in, lower animals. For instance, our ear has at least three small muscles (22, 23, 24) connected with it. These are rarely capable of moving the ear in man, but in such an animal as the horse they attain a great development, and effect those characteristic movements of the ears that constitute such a large part of equine expression. So also with the muscles which close the nostrils in lower animals, these latter being rudimentary in man (3, 4, 5, 6), but very highly developed in such animals as the seals, where necessity arises for closing the nostrils' apertures against the admission of water.

Although it is impossible to lay down any fixed rules on the subject, it may be affirmed as a general result that relaxation of the muscles is as a rule associated with pleasurable states of mind, whilst violent contraction generally accompanies the painful phases of mental action. The state of dreamy contentment, for instance, best

illustrates such a general relaxation of the muscles as accompanies pleasurable emotions. Even in active joy, as in laughing, additional relaxation takes place, accompanied however by contraction of the "zygomatic muscles" (11, 12), which draw the corners of the mouth upwards and backwards.

The mere mechanism of muscular acts is thus not difficult of comprehension, and in connection with this part of our subject it may not be amiss to deal briefly with modes of expression subsidiary to those of the "mind's index," such as the movements of the hand and of other regions of the body liable to be affected in a very definite manner in the play of the passions. In the seventeenth century a certain John Bulwer published a curious volume entitled "Chirologia, or the Natural Language of the Hand." As the face was named the "Dyall of the Affections," so Bulwer applies to the hand "the Manuall text of Utterance." "The gesture of the hand," according to Bulwer, "many times gives a hint of our intention, and speaks out a good part of our meaning, before our words, which accompany or follow it, can put themselves into a vocal posture to be understood." Again, this quaint-spoken author remarks that "the lineaments of the body doe disclose the disposition and inclination of the minde in generall, but the motions doe not only so, but doe further disclose the present humour and state of the minde and will, for as the tongue speaketh to the ears, so Gesture speaketh to the eye, and therefore a number of such persons whose eyes doe dwell upon the faces and fashions of men, doe well know the advantage of this observation, as being most part of their ability; neither can it bee denied but that it is a great discoverer of dissimulation and great direction of businesse. For, after one manner almost we clappe our hands in joy, wring them in sorrow, advance them in prayer and admiration: shake our head in disdaine, wrinkle our forehead in dislike, crispe our nose in anger, blush in shame, and so for the most part of the most subtile motions."

In some subsequent advice given in his "Philocophus; or the Deafe and Dumbe Man's Friend," Bulwer asks of his readers, "What though you cannot express your mindes in these verball contrivances of man's invention;" (Bulwer really anticipated the most modern view of the origin of language); "yet you want not speech who have your *whole body* for a Tongue: having a language more naturall and significant, which is common to you with us, to wit, Gesture, the general and universall language of Humane Nature, which, when we would have our speech to have life and efficacy, wee joyne in commission with our wordes, and when wee would speak with most state and gravity, we renounce wordes and use *Nods* and other naturall signes alone." Thus does Bulwer vindicate the eloquence of silent sign-speech, which in its earliest development probably aided very largely in the formation and development of language itself. As the

infant's gesture precedes its speech, so in the early phases of man's development the sign-speech probably served as a means of communication ere the principle of imitating natural sounds led to the first beginning of language. Besides the play of the hands, the movements of breathing may be ranked as amongst the means for the due expression of the emotions. Sir Charles Bell speaks of the "respiratory" group of nerves as highly distinctive of man, and maintains that they were developed to adapt the process and organs of breathing to man's intellectual nature. Such an explanation would, of course, be utterly rejected by the evolutionist, who maintains that the means possessed by man for the expression of the emotions are explicable on utilitarian and allied grounds as having been generated by outward favouring circumstances and perpetuated by habit, or as having arisen from the perpetuation of traits of expression found in lower forms of life. The altered movements of breathing seen in the paroxysm of terror or grief, are more or less secondary effects of the emotions; they are seen equally well in the fear of many quadrupeds; and they hardly fall into the category of direct effects illustrated so markedly by the flitting shadows of the face or by the gesture language of the hands and body. Not the least interesting feature of the present subject exists in the obvious connection between the formation of words expressive of certain strong emotions, and the physical or bodily expression by the face of similar feelings. Reference has already been made to this correspondence, but the topic will bear an additional mention before we pass to consider the probable origin of the modes of emotional expression, by way of summing up the present paper. As already quoted from Dr. Maudsley, the fact of a spoken word relating itself to the idea of which it is the expression, is a well-known feature of our everyday mental existence. Many of our most primitive emotional traits bear to the words whereby we express them the relation of cause to effect. Take as an example the expression "Pooh!" What better explanation of this otherwise meaningless but at the same time expressive term can be afforded, than that it arises from the natural expiratory effort produced by, or at least naturally associated with, the protrusion of the lips in the act of rejecting some undesirable substance. The labial movement of expression gives rise to a sound which becomes convertible into the term for disgust. The "hiss" of contempt is explicable on similar grounds; and the word "ugly" is by no means the unlikely offspring of that "ugh" which is so plainly associated with the expression of contempt and disgust.

These observations regarding the nature and mechanism of the emotions have already extended to a considerable length, and it now behoves us to summarise them shortly in the question of their

development. The subject of the emotions and the origin of the means whereby we express them, like so many other subjects of physiological inquiry, received a decided impetus from the publication of Mr. Darwin's works. His "Expression of the Emotions" has already become well-nigh as classic a work as Sir Charles Bell's treatise; and the query how far Mr. Darwin's views assist us in explaining the origin of the expressions, may best be answered by showing the chief grounds upon which Mr. Darwin's explanations are based. That his views do not overtake all the difficulties of the subject, Mr. Darwin would be the first to admit; but it is equally undeniable that he makes out a strong case for the reception of his views, namely, that inheritance of traits from lower forms of life, together with modifying circumstances—such as the perpetuation of useful habits—acting upon human existence, have been the main causes of the development of expression.

On three principles, according to Mr. Darwin, we may account for most of man's gestures and expressions. The first, he terms that of "serviceable associated habits." Under this first head, Mr. Darwin remarks the influence of habit and custom in perpetuating acquired movements, illustrated in the peculiar "step" of horses, and the "setting" and "pointing" of dogs. Even gestures of the most unusual type have been known to be perpetuated in human history. "A boy had the singular habit," says Mr. Darwin, "when pleased, of rapidly moving his fingers parallel to each other; and, when much excited, of raising both hands, with the fingers still moving, to the sides of his face on a level with the eyes; this boy, when almost an old man, could still hardly resist this trick when much pleased, but from its absurdity concealed it. He had eight children. Of these, a girl, when pleased, at the age of four and a half years, moved her fingers in exactly the same way, and what is still odder, when much excited, she raised both her hands, with her fingers still moving, to the sides of her face, in exactly the same manner as her father had done, and sometimes even still continued to do when alone. I never heard," concludes Mr. Darwin, "of any one excepting this one man and his little daughter who had this strange habit; and certainly imitation was in this instance out of the question." Again, during sound sleep, three generations of a particular family have been known to raise the right arm up to the forehead and then allow it to drop "with a jerk, so that the wrist fell heavily on the bridge of the nose." Such an act—altogether without known cause—might sometimes be "repeated incessantly for an hour or more," and the person's nose, as was naturally to be expected, gave palpable evidence of the treatment to which it had been subjected. The son of this person married a lady who had never heard of this incident, but in her husband she chronicled the same history as did her

mother-in-law. One of this gentleman's daughters has inherited the same peculiarity, modifying the action, so that the palm and not the wrist strikes the nose. In lower animals many such illustrations of truly serviceable habits might be given. The perpetuation of such habits is simply a matter of "reflex nervous action"—as much, indeed, as the unconscious act of drawing back the hand from a burning surface, or of closing the eyes in a sudden flash of light. On this first principle, then, we may explain many forms of expression, as depending upon sensations of varying nature which first led to voluntary movements; and these latter, in turn, and through the ordinary laws of nervous action, have become fixed habits, notwithstanding that they may be perfectly useless to the animal form. In their most typical development, such expressions appear before us as the results of inheritance. No better illustrations of such inherited habits in man could be found than in the numerous acts which accompany furious rage and vexation, or the fighting attitude in which an opponent is defied without any intention of attack. And on some such principle as the foregoing may we reasonably enough explain the act of uncovering the eye-tooth before alluded to, in the act of snarling or defiance. "This act in man reveals," says Mr. Darwin, "his animal descent, for no one, even if rolling on the ground in a deadly grapple with an enemy, and attempting to bite him, would try to use his canine teeth more than his other teeth. We may readily believe," adds our author, "from our affinity to the anthropomorphous apes, that our male semi-human progenitors possessed great canine teeth, and men are now occasionally born having them of unusually large size, with interspaces in the opposite jaw for their reception."

Mr. Darwin's second principle on which the expression of the emotions and their origin may be accounted for, he terms that of "antithesis." By this term he means to indicate the fact that certain mental states lead to certain definite acts, which, as just explained by the first principle, may be serviceable to the animal—or which may in time lose both their serviceable tendency and their original meaning, as we have also seen. Now, if we suppose that a directly opposite phase of mind to these first mental states is produced, actions may follow which will express the latter and not the original states. These antithetical and antagonistic actions are of no use, but at the same time they may be expressive enough. The dog who approaches an intruder with irate growl, erect head and tail, stiff ears, and a general attitude of attack, on discovering that he has been menacing a friend, at once changes his expression. He fawns upon the supposed antagonist, becomes servile to a degree, and completely reverses his former attitude. Such is an example of the antagonistic nature of certain modes of expression, which are ex-

plicable, Mr. Darwin holds, only on the supposition of their antithetical nature. The servile or affectionate movements of the dog are of no direct service to the animal, but represent the mere revulsion of feeling which represents nerve-force or emotion speeding into channels of opposite nature from those into which in the angry condition they had been directed. The shrugging of man's shoulders may be selected as the best example of the antagonistic methods of expression. Here we confess by sign language our inability to perform an action, or as often exhibit a total indifference to the matter in hand—the polite *comme il vous plaira!* accompanied by this gesture, placing the latter before us in its true significance. As to the origin of the expression, it may perhaps be most clearly explained, as Mr. Darwin holds, by regarding it as the antithetical and passive phase of actions and expressions which had for their object some very active and direct piece of business—most probably that of attack.

The third and last principle used to explain the origin of the emotions is more strictly a matter of pure physiology than the preceding conditions. Mr. Darwin terms this last a principle involving "the direct action of the nervous system." It acts independently of the will from the first, and is independent to a certain extent of habit likewise. A strong impulse or steady impression sent through the brain causes a correspondingly large expenditure or liberation of nerve force, which escapes by those channels which are first opened for its reception, and thus produces very varied and marked expressions. In such a category we might place the remarkable changes which grief is known to effect in the colour of the hair, as for instance where, in a man led forth to execution in India, the hair was seen to undergo a change of colour as the culprit walked. Muscular tremor and the quaking of limbs—paralleled by the more severe convulsions from fright of hysterical persons and young children—are forms of expression which cannot be explained save on the idea of nerve-force speeding along the channels, which, through some unknown condition of the nervous system, have been opened for its reception in preference to others. So also the phenomena of blushing illustrate Mr. Darwin's third principle, which might well be termed the diffusion of nerve force, modified by habit, by inheritance, and by personal peculiarities. Here a mental emotion is transferred to the skin-surface, and especially—but not invariably—to the face, producing the well-known tinge which Wilkinson, in his "Human Body and its connection with Man," describes as the "celestial rosy red," and which he defines as the "proper hue" of love: whilst "lively Shame blushes and mean Shame looks Earthly." Carried to an extreme degree, as in the case of the Belgian "stigmatics," the same emotion produces the bleeding

points of the religious devotees, of whom St. Francis himself is the type. The earlier writers on expression contended that blushing was specially designed from the beginning, that—according to one author—"the soul might have sovereign power of displaying in the cheeks the various internal emotions of the moral feelings." To explain blushing on more reasonable grounds, it is necessary to have recourse to the idea that a sensitive regard for the opinions of others acts primarily on the mind—inducing a play of emotion which, coursing through the nerves regulating the circulation of the face especially, results in the dilatation of the minute bloodvessels of the part to which attention has been directed. Concentration of attention on the face lies at the root of the mental act involved in blushing, and that such attention has not escaped the effects of habit and inheritance is the safest of conclusions founded on the common experience of our race.

It remains, finally, to direct attention to the general proofs which the evolution theory, resting the origin of human emotions chiefly upon the idea of our derivation and descent from lower stages of existence, is entitled to produce by way of supporting the latter conclusion. It is very noticeable that the will has, at the most, but little share in the development of the emotions, just as in many cases (*e.g.*, the phenomena of blushing) it is powerless to hinder their expression. Nor have most of the typical modes of expression been newly acquired—that is, they do not appear as our own and original acts—since many traits are exhibited from our earliest years, and may then be as typically represented as in later life. Equally valuable is the evidence which the observation of abnormal phases of the human mind reveals in support of the inherited nature of our chief emotions. The blind display the typical emotions (*e.g.* blushing) equally with those who see. Laura Bridgman, the educated deaf-mute, laughed, clapped her hands, and blushed truly by instinct and nature, and not from imitation or instruction. This girl likewise shrugged her shoulders as naturally as her seeing and hearing neighbours, and nodded her head affirmatively and shook it negatively by a similar instinct. Not less remarkable, as testifying to the inherent nature of human expressions, is the experience of the physician who labours amongst the insane. The idiot will cackle like a goose as his only language, or give vent to monosyllables which are little above the simple cries of the animal world in complexity or meaning. Every act and expression is not originally of the man but of the truly animal. "Whence come the animal traits and instincts in man? . . . Whence come the savage snarl, the destructive disposition, the obscene language, the wild howl, the offensive habits, displayed by some of the insane?" "Are these traits," asks Dr. Maudsley, "really the reappearance of a primitive instinct of animal nature—a

faint echo from a far distant past, testifying to a kinship which man has almost outgrown, or has grown too proud to acknowledge? No doubt such animal traits are marks of extreme human degeneracy, but it is no explanation to call them so; degenerations come by law, and are as natural as law can make them. . . . Why should a human being deprived of his reason ever become so brutal in character as some do, unless he has the brute nature within him?" "We may," concludes this eminent authority, "without much difficulty trace savagery in civilisation, as we can trace animalism in savagery; and in the degeneration of insanity, in the *unkinding*, so to say, of the human kind, there are exhibited marks denoting the elementary instincts of its composition."

These are weighty words; but the grounds on which they are uttered amply justify their conclusions. Turn in which direction we will, we meet with evidences of man's lowly origin—now in a plain proof of his kinship with lower forms, now in a mere suggestion presented in some bypath of nature, showing us a possible connection with humbler grades—and even in the passing flash of emotion which, sweeping across the mirror of the mind, reveals the workings of the soul within, we may find, as in a random thought, a clue to the origin of our race.

XIII.

WHAT DREAMS ARE MADE OF.

THAT our existence, in a physiological sense, may be regarded as consisting of alternating periods of activity and repose is an axiom which requires no very deep reflection or research for the demonstration of its truth. The waking hours of the day are succeeded by the resting hours of the night. The work of life is followed naturally by the repose which, in its turn, is equally a part of our normal existence; and there are too many obvious indications that this succession of events is part and parcel of nature at large, to leave room for doubt that sleep and wakefulness are simply the evenly balanced ends of the vital "see-saw." It appears to be a rule of physical life that, even in its most intimate and less apparent phases, an alternation of rest and repose should be constantly exemplified. The work of life means, of course, the dissipation of energy. The wear and tear inseparable from the mere act of living and being necessitates proportionate repair. This much is contained in the first pages of the scientific primer; whilst a succeeding and equally primitive study discloses the way of repair in the many processes of nutrition which tend to preserve the form of the individual in its stable aspect by counteracting the inevitable waste of life.

But there are other processes and functions which seem to contribute to the latter end, and amongst them we may legitimately number the influence of rest and repose. It is by no means paradoxical to assume that the very act of nutrition or that of bodily repair, involving as it does a large expenditure of energy, is in itself a source of bodily wear and tear. The pulsations of the heart, directly concerned in the distribution through the body of the products of nutrition, represent, apparently, an amount of exertion and work which well-nigh induces the belief that we subsist on a veritable "peau de chagrin," and that even the gains of the body of necessity imply a loss. From the physiological side of things, however, there comes a gleam of comfort in the declaration that the nutrition of rest serves to counterbalance the wear and tear involved in the mere fact of existence. In repose is found, we are told, a highly perfect source of bodily repair. And it is further impressed upon us that this cessation from labour may occur in ways and fashions undreamt of by the casual observer of the lives of men. Take as an example the heart itself. Next to the brain,

which is credited with being the scene of a never-ending bustle and traffic in ideas, the heart may be thought of as an organ whose duties permit of no cessation or repose. Even in the ordinary undisturbed performance of its functions, the rhythmical routine of the great pumping-engine strikes us as resembling that of the galley-slave chained to the oar, and as exhibiting day by day the same unflagging, stereotyped way of life and action. The question of rest for such an organ might at first sight appear non-existent. Its nutrition likewise would seem to be a matter in arranging for which, conformably with its perpetual round of duties, nature might experience some difficulty; since, like the through railway guard on an extended journey, it must feed as it runs.

But the dilemma in question is solved through the simple consideration of the manner in which the heart's work is performed. The action of the organ, as every one knows, is not continuous. Its work is intermittent in character, as may be proved by listening to the sounds it makes. It has its periods of repose, short as these may be, between its strokes of work. It takes its rest in short alternate naps; and if we sum up its life history, and calculate its working hours, we shall find that, in truth, the heart has rested for a longer period than it has worked. Thus although the snatches of rest be short, in the case of the heart they are really as frequent as its working moments, and in the intervals betwixt its pulsations it may be said to gather energy for its succeeding strokes. The case of the muscles used in breathing—and it may be borne in mind that the heart itself is simply a hollow muscle—is equally interesting, and certainly not less typical than that of the central organ of the circulation. The periods of work, so to speak, are longer in the case of the chest-muscles, just as the intervals of repose are more protracted than in the business of the circulation. And if the idea of rest alternating with work be extended to other departments of bodily activity, we shall find that the practice in question prevails throughout the living organism. The chief differences between the action of one set of muscles and that of another set consist in the varying duration and succession of the periods of work and rest. In absolute cessation from labour, then, we find a profitable source of repair of the body. Then it is that the materials derived from the food can be perfectly applied to the necessities and wants of the frame. The true justification of sleep is found after all in the value of rest as a reparative measure. And the after-dinner nap of well-favoured humanity, equally with the somewhat prolonged post-prandial inactivity of the boa-constrictor, are procedures separated, it may be, by an infinity of differences, but which, perchance, derive much of their reasonableness from the physiological considerations besetting the question of repose.

As a knowledge of the nature of sleep becomes a necessity for

the understanding of the why and wherefore of dreaming and allied conditions, we may in the next place endeavour to gain some ideas respecting certain curious states which in one way or another may be said to border the "land of Nod." Such are the remarkable cases of producing insensibility or of feigning death at will, and those which relate to the production of unnatural states allied to sleep, and which in some measure aid our understanding of dreams and their causation. As in many other acts and phenomena connected with brain and mind, the phenomena of sleep and dreams do not stand alone or unconnected with other mental states. On the contrary, it is possible to trace well-marked gradations leading from the day-dream to the reverie, and from these common instances of abstraction to the somnolent condition itself. Nay, it may also be said that the full understanding of dreaming, in so far as that is possible at present, can only be arrived at from a knowledge of the facts which a study of the waking dream or the automatic patient teaches us. Through morbid and unwonted conditions, as in so many other instances in the search after knowledge, we arrive at a comprehension of the ill-understood affairs of common life.

That there exists a power of producing at will conditions allied in nature to sleep, or even extending to deep insensibility with apparent cessation of the physical processes of life, is a well-known fact of physiology. A condition approaching that of coma or insensibility thus appears to be occasionally induced in man by an effort of the will. In many animals a prolonged and periodical suspension of the activities of ordinary existence normally occurs and is designated under the term hybernation. The bear, squirrel, dormouse, and bat exemplify this condition, in which, however, respiration is unimpeded, although its frequency is reduced; and the animal, retiring to its winter quarters fat and well favoured, emerges in spring in a lean condition. The nutritive principal which was accumulated in the preceding summer has, in fact, been converted into an account-current and used in the maintenance of the slumbering organism. In such a case there is simply deep somnolence and suspension of all ordinary activity and of the exertions and waste attending the wakeful state. But a step further brings us to the domain of pathology (or the science of disease) with its unwonted states, depending on disease or on conditions which approach those of abnormal existence. Celsus speaks of a priest who could separate himself from outward existence at will, and lie as one dead. But the case of Colonel Townshend, related by Dr. George Cheyne—in his quaint book entitled "The English Malady; or, a Treatise of Nervous Diseases of all kinds, as Spleen, Vapours, Lowness of Spirits, Hypochondriacal and Hysterical Distemper, &c., London, 1733"—justly exceeds in interest any other known case of the kind, not merely for the abnormal nature of the phenomena, but also from

the exact account of the events in question, related by accurate observers trained in the scientific methods of their day.

Dr. Cheyne's account of this case bears that Colonel Townshend had suffered from some internal malady, of ascertained and well-understood nature, and that he came in a litter from Bristol to Bath in autumn for the purpose of obtaining medical advice. Attended by a Dr. Baynard, a Mr. Skrine, his apothecary, and by Dr. Cheyne himself—all three despairing of the Colonel's recovery—the patient sent one morning for his medical attendants, and intimated that he had made his will and set his house in order; "his *Senses*," according to Dr. Cheyne, being "clear, and his *Mind* calm." Colonel Townshend next informed his doctors that he had sent for them that he might give them details of "an *odd* Sensation he had for some Time observed and felt in himself: which was," continues Dr. Cheyne, "that, composing himself, he could *die* or expire when he pleased, and yet by an *Effort*, or somehow, he could come to Life again, which it seems," adds the author, "he had sometimes tried before he had sent for *us*." On hearing such a recital, the doctors were naturally astonished. As men of science, their natural scepticism of the unusual, until proved by experiment to be likely or true, exhibited itself in Dr. Cheyne's declaration that his hearers "could hardly believe the Fact as he related it, much less give any Account of it, unless," adds the narrator, "he should please to make the *Experiment* before us, which we were unwilling he should do, lest, in his weak Condition, he might carry it too far." The Colonel, however, insisted on the trial being made, the preliminary duty of feeling his pulse being duly performed, when it was found to be "distinct, though small and *threedy*": whilst "his *Heart* had its usual Beating."

Dr. Cheyne may now be allowed to relate the sequel in his own words: "He composed himself on his Back, and lay in a still posture some time; while I held his right Hand, Dr. *Baynard* laid his Hand on his *Heart*, and Mr. *Skrine* held a clean Looking-Glass to his Mouth. I found his *Pulse* sink gradually, till at last I could not feel any, by the most exact and nice Touch. Dr. *Baynard* could not feel the least motion in his *Heart*, nor Mr. *Skrine* the least Soil of Breath on the bright *Mirror* he held to his Mouth; then each of us by *Turns* examined his *Arm*, *Heart*, and *Breath*, but could not by the nicest *Scrutiny* discover the least *Symptom of Life* in him. We reasoned a long Time about this odd *Appearance* as well as we could, and all of us judging it inexplicable and unaccountable, and finding he still continued in that Condition, we began to conclude that he had indeed carried the *Experiment* too far and at last were satisfied he was actually dead, and were just ready to leave him. This continued about half an Hour. By Nine o'Clock in the Morning in autumn, as we were going away, we observed some Motion about the Body,

and upon Examination found his *Pulse* and the *Motion* of his *Heart* gradually returning; he began to *breath* gently and speak softly: we were all astonish'd to the last Degree at this unexpected Change, and after some further Conversation with him, and among ourselves, went away fully satisfied as to all the Particulars of this Fact, but confounded and puzzled, and not able to form any Rational Scheme that might account for it." Thus far Dr. Cheyne. The sequel relates that after calling for his Attorney and adding a codicil to his will, Colonel Townshend "received the *Sacrament*, and calmly and composedly Expir'd about five or six o'Clock that Evening."

Thus it appears to be proved beyond doubt that this patient had the power of composedly and perfectly simulating death at will—for Dr. Cheyne expressly mentions that Colonel Townshend had "for some Time observed and felt in himself" the peculiar power of which he gave his physicians such satisfactory demonstration. There are few amongst ourselves who will not appreciate to the full Dr. Cheyne's concluding remark, that, having "narrated the Facts," deliberately and distinctly, he may well "leave to the *Philosophick Reader* to make what Inferences he thinks fit." In addition to all the signs and symptoms of sleep, we have added in Colonel Townshend's case the power of intensifying the conditions of somnolence to an extent comparable only to the extinction of vital action itself.

A case reported in the *Medical Times and Gazette* and *British Medical Journal* for 1863 may interest us as presenting us in some measure with a case comparable in man to the hybernating habits of lower forms, and which may also serve as a connecting link between such a case as the previous one and the phenomena of ordinary sleep. A man, aged forty-four years, began in 1842 or 1843, after a severe cold, to exhibit a tendency to indulge in deep and prolonged sleep. The affection returned in 1848, and again in 1860 and in 1866. During the attack his appearance was natural, but the face and ears were pale, feet often cold and livid, respiration scarcely perceptible, and pulse feeble. The account adds that on awakening, the patient felt refreshed. The longest period he passed in sleep was five days and five nights. Frequently a period of three or four days was passed in sleep, the average duration of the attacks being two days, whilst he was awake during four or five hours out of the forty-eight. He did not dream during the period of repose. These remarks apply to his history up to 1860. In 1866 the curious phenomena were again noticed. The patient slept from about 11.30 P.M. on January 2, 1866, to 2 P.M. on January 6. At 12 P.M. on February 4 another period of repose began, which lasted until 4 P.M. on February 8; when after a wakeful interval of seven hours he dozed off again until the 11th, when he remained awake for nine hours, but thereafter slept for four days. From February 16 till February 26 he slept continu-

ously, save for an interval of five hours; and beginning to sleep on March 9 at 10 A.M., he slept until the 15th at four o'clock in the afternoon. Nothing remarkably abnormal or in the least sufficient to explain the anomalies of this patient's existence was revealed by an examination of the brain after death, which occurred at the close of the year last mentioned. Here the tendency to sleep was a matter of abnormal action of some mysterious kind. There was no power, as in Colonel Townshend's case, to induce the phenomena at will; but the nature of the conditions inducing or favouring the peculiarities remains in either case an insoluble mystery.

The occurrence of such anomalous cases receives no direct explanation from any of the conditions which are known to be characteristic of normal sleep. The resemblance of the insensibility produced by congestions and fulness of blood in the brain to natural sleep long ago suggested that, in some such mechanical cause as a normally recurring fulness of the vessels of the organ of mind, a cause of sleep might be found. But the analogy between induced insensibility and sleep is not complete or correct. There exist many and wide differences between the production of coma or stupor and that of a normal insensibility to outer affairs, which sooner or later resolves itself into wakefulness; and the conditions observed in the sleeping brain were, moreover, widely at variance with the known symptoms of abnormal insensibility. In 1821 a Dr. Pierquin, of Montpelier, placed on record the observation that in a patient, part of whose brain was exposed through disease, there was no movement of the organ of mind in ordinary undisturbed and dreamless sleep. When, on the contrary, the sleep was disturbed by dreams, the brain substance was elevated in proportion to the vivid nature of the dream. In her waking state, this patient exhibited the same appearances; there was marked activity of the brain when she was engaged in lively or excited conversation. Experiment has, however, proved to us that without doubt the brain-substance receives less blood during sleep than in the waking state, which latter is accompanied by an increased flow of blood to the organ. Such a result is exactly that which the general inductions of physiology might have foretold. Blood passing to the brain is required and used for two purposes—namely, for the nutrition and physical conservation of the organ, and for supplying the potential energy, to be converted into thought, nerve-force, and the acts of life. During sleep, therefore, blood will be demanded for the first purpose alone. The wakeful activity which demands and requires the larger blood-supply is no longer represented, save, indeed, under abnormal conditions. And we thus arrive at a basis for constructing a theory of sleep and its causation, just as, at the commencement of this paper, we discovered a plain justification for its occurrence as an act and part of life.

Sleep is produced by those causes which favour the withdrawal of blood from the brain, or rather by those which lessen the flow and force of the circulation in that organ. As an indication of the need of repair by rest, the bloodless condition of the sleeping brain appears in perfect harmony with the opposite condition of the wakeful state. And thus, also, it may be added, we may construct a reasonable approach to a theory of dreams in the statement that whatever favours an increase of brain-circulation during sleep will develop the dream-instincts, and liberate those dream-children which, Shakespeare notwithstanding, are not to be declared the offspring of "an idle brain."

That we have a power or faculty of abstracting our thoughts—and practically ourselves—from the external order of things by which we are surrounded, is, of course, a statement which has but to appeal to our common experience to attest its unquestioned veracity. It is important for our present purpose that we briefly glance at the subject of reverie, inasmuch as we may find a striking analogy between this state as experienced in our wakeful moments, and through the allied state of "automatism," an explanation of the mechanism of dreams. The ordinary sensation, received by an organ of sense from without, is transferred to some part of the brain specially concerned with the registration of such an impression, and is there converted into an idea. This idea in turn may be reflected hither and thither through the body, and appears in our waking life as a defined and purposive action. Suppose, now, that ideas which have been registered in the brain are capable of being despatched or evolved therefrom at will. The production of thoughts thus-wise constitutes memory; and association duly links them together to form "a train of thought." But thought may be unattended by action. A whole train of ideas, or a complicated chain of reasoning, may be thought out in a kind of mental aside, and in that utter want of attention to our surroundings which constitutes the essential feature of the "absent-minded man"—a phrase applicable only in so far as the term "absent-minded" applies to the immediate circumstances of the individual. Here there is *automatic* action of the brain pure and simple. The familiar instance of the rapid walk through the crowded streets of a city, whilst the mind is engaged in the pursuit of some recondite subject, is but another instance of the phenomena of abstraction carried into practical effect, and exemplifies an intermediate state between sleep and waking allied to somnambulism itself. From our wakeful moments to the reverie in our arm-chair is but a step. From such a reverie to the abstraction of our city walk is only another advance; and if we suppose the abstraction to deepen whilst the mental activity becomes annihilated, we obtain the dreamless sleep, as, on the other hand, with an increase of the

mental activity, we ally ourselves to the dreamer and to the sleep-walker himself.

It is a curious circumstance that in certain individuals the faculty or habit of abstraction may become so thoroughly developed that the subject is to all intents and purposes an automaton pure and simple, and may be said to dwell on the borders of the somnambulistic state itself. The latter opinion alone can be expressed regarding the well-authenticated case of the clergyman who, engaged in an abstruse mathematical calculation, was reminded by his wife that it was time to dress for dinner. The gentleman in question proceeded upstairs to his bedroom still deeply involved in his thoughts, with the result of being found, soon thereafter, in the act of getting into bed—a proceeding simply suggested to the semi-unconscious mind and well-nigh absent volition by the act of entering his bedchamber and commencing to undress. Only on the supposition of habit having developed this awkward faculty of allying oneself to a species of sleep in the hours of wakefulness can the doings of a late well-known Scottish Professor be accounted for. This gentleman passing out of college on one occasion ran against a cow. Pulling off his hat amid his abstraction, he exclaimed, "I beg your pardon, madam!" Although aroused to a sense of his mistake, shortly thereafter he stumbled against a lady under somewhat similar circumstances, greeting his astonished neighbour with the remark, "Is that you again, you brute?" It was this gentleman who bowed to his own wife in the streets, but remarked that he had not the pleasure of her acquaintance; whilst another vagary consisted in his making his appearance at college in the costume of his day, displaying on one leg a black stocking of his own, and on the other a white stocking of his better half. Another narrative credits the Professor with addressing a stranger in the street and asking this person to direct him to his own house. "But ye're the Professor!" replied the interrogated and astonished person. "Never mind," was the reply, "I don't want to know who I am—I want to know where the Professor lives!"

Such is a brief account of the condition we term Abstraction, serving to bridge over the gulf between the waking state and sleep; and the analogy becomes closer still if we venture to compare a well-authenticated case of so-called "automatism" in man, and thereafter to compare the details of such a case with the acts and behaviour of the absent-minded man, on the one side, and with those of the somnambulist on the other. The best-authenticated case of automatism pure and simple in man is the famous case of the French Sergeant F., reported by Dr. Mesnet. When twenty-seven years of age F. was wounded on the left side of the head by a ball. Immediately thereafter, his right side being paralysed, he became senseless.

Three weeks afterwards he awoke to consciousness in the hospital at Mayence.

For a year the paralysis of the right side continued, but this condition improved under treatment. Curious periodical aberrations of the intellect, however, began to appear about three months after his mishap. These latter symptoms occurred at intervals, varying from fifteen to thirty days, and they lasted from fifteen to thirty hours. His abnormal periods were therefore short, as compared with his normal ones. The peculiarities of his abnormal period were very marked. His eyes were wide open; his movements were regular but automatic; he went wherever he was directed; when he stumbled over an object he felt about for the obstruction and then passed on one side; and he ate and drank as usual, and rose and retired to rest at his accustomed hours. More curious was the fact that pins might be run into his body without eliciting the slightest exclamation of pain. To electricity he was equally insensible; he heard not, but rarely saw, and did not distinguish what he ate or drank. His sense of touch alone was present, and that in an elevated degree; but curiously enough, when placed in an appropriate position, he might be made automatically to express in pantomime the movements of reconnoitring or skirmishing in an enemy's country. He could hum a tune, and sang from a roll of paper placed in his hand as if it were a vocal score; and, as refreshment, swallowed between his songs, without grimace, a mixture of strong vinegar and water. That the sense of sight, although deficient, yet played a part in directing the abnormal life of F., was apparent in an experiment of Dr. Mesnet's, in which, when engaged in writing a letter, a screen was interposed between his eyes and his letter. The sergeant proceeded for a little time with his letter, finally, however, coming to a halt as his words became illegible, but without exhibiting a sign of annoyance; and when sheet after sheet of a superimposed series was withdrawn as he wrote, so that each sheet contained but a few words of his letter, he continued to write on, signing his name on the last sheet as if it contained the whole of his communication, and correcting the imaginary writing which he supposed was represented before him. His tobacco pouch being removed after the manufacture of a first cigarette, he neither saw nor smelt the missing object, but when placed in his hand the automatism of his nature asserted itself, and another cigarette was duly manufactured.

The seats of the senses in the brain, or "sensory ganglia," as they are named, may apparently serve as centres of action, even when the purely intellectual functions of the brain proper (or "cerebrum") are practically in abeyance; and such a remark, moreover, leads us to understand how in the phases of somnambulism, when mind proper is annihilated, there are performed movements and acts involving

extreme caution, tact, and delicacy in their performances. From a long list of interesting examples, tending to prove the power of the sensory masses of the brain to guide the body in the absence of normal power of thought and will, we may select the following. Complete idiots, such as crétins of the first degree, spend their whole time, says Dr. Carpenter, basking in the sun or before the fire, but they nevertheless pass regularly, when excited by hunger, to the sources of their food-supply. A man whose history is given by Dr. Rush, being violently affected by losses in trade, was instantly deprived of his mental faculties. He took no notice of anybody or anything, nor did he express a desire to eat, but simply received his food when placed in his mouth. He was dressed in the morning, led to his chair, where he remained all day with inclined body, and eyes fixed on the floor. For five years he remained thus, but recovered suddenly and completely.

A sailor who had sustained an injury to his head lived in much the same condition for about a year. The fractured bone being raised, he recovered; but the whole period intervening between his injury and the operation was a complete blank to his mind. The most notable case of this kind, showing the likeness of the purely sensorial state of life to the dream—and also giving the transition-stage connecting the sensory state and the intelligent life of every day—thus linking the dream with waking life, was that of a young woman who, previously in good health, fell into a river, lay insensible for six hours, and in ten days' time lapsed into a fit of stupor. From this she recovered in four hours, only to find that the power of speech and the senses of taste, smell, and hearing were in total abeyance. Sight and touch aroused no *ideas*, though automatically responsive movements attended the operation of these two senses. Her vision at short distances was quick, and her general sensibility exceedingly acute. Friends and relations were unrecognised, and she ate, without a sign of disgust, the most nauseous substances. She made no effort to feed herself, but when the spoon had a few times been conveyed to her mouth she automatically continued the act of feeding. Gradually she appeared to acquire ideas, and formed imitations of flowers from paper with which she was supplied; and this process of educating her mind as if she were still a child proceeded until she was able to do worsted work. Ultimately ideas connected with her *past* experiences began to dawn upon her. A picture of a troubled sea agitated her from the dull remembrance of her unpleasant association with water; and the sight of a young man to whom she had been attached gave her pleasure, whilst she became fretful when she did not see him at the accustomed times. Thereafter she took notice of her surroundings, began to articulate a few words, and exhibited in due course normal symptoms of emotion when she knew that her lover was paying atten-

tions elsewhere. After a fit of stupor excited by jealousy she really awoke from a sleep of a year's duration, to find herself surrounded by her friends at Shoreham, and in the full possession of her natural faculties, save hearing, but without the slightest remembrance of her acts in her year of mind-abeyance.

There is little need to pursue these strange but instructive histories further, and we may now profitably turn to consider the parallelism between the automatic patient, the somnambulist, and the victim of commonplace abstraction. The somnambulist has in all ages excited the curiosity, often the fear, and not unfrequently the superstition of his fellow-men. By Horstius we are told that sleep-walkers were named "the ill-baptized," from an idea or belief that their acts arose from part of the ceremony of baptism having been omitted, and from the consequent misrule of evil spirits. This writer himself, whilst opposing this view of matters, strongly leans to the belief that somnambulists represented prophets and seers who were guided and influenced by angels. In any case, it is by no means strange that the incidents of the sleep-vigil should have impressed the early mind with notions of a connection with an unseen universe. In the study of the sleep-vigil, we meet as before with stages and gradations which carry us from the waking dream or reverie to the more typical form of somnambulism proper. A form of sleep-vigil is known, for instance, in which the subject passes naturally, and without a disturbing interval, from the abstraction of the waking state into true somnambulism. Galen himself relates that he fell asleep whilst walking, and was aroused by striking his foot against a stone. Other cases are common enough in medical pages, in which persons have continued to play a musical instrument for some time after falling asleep, and similarly a reader and speaker has continued his recital during the earlier part of a sound nap. Here there is exemplified the passage, without a break, from abstraction to somnambulistic action. It is difficult, indeed, to find adequate grounds for drawing any hard-and-fast line of demarcation between the person who "thinks aloud" in his day dream, and the speaker who, fast asleep, continues his flow of oratory.

But the more typical cases of sleep-vigil present us with a further development of practical wakefulness amid abstraction from outward affairs of the most complete kind. To the consideration and explanation of natural somnambulism we are aptly led by the details of that artificial sleep-vigil which has received the popular name of "mesmerism" or "hypnotism." It is not our intention to say anything in the present instance regarding a subject which in itself presents material sufficient for a lengthy and extended investigation: we may, however, briefly glance at the essentials of this curious state in its especial relations to somnambulism and dreams. All physiologists

are agreed that the explanation of the curious phenomena, which Mr. Braid, of Manchester, was the first to examine and report upon scientifically, rests in the fact that the hypnotised subject is firstly an easily impressed or susceptible person, and secondly, that the attention is fixed and strained under the influence of a powerful will and of a dominant idea or ideas proceeding from the operator. In his trance-like state, the subject is completely dominated by the ideas of the mesmeriser. As Dr. Maudsley remarks, "He feels, thinks, and does whatever he is told confidently that he shall feel, think, and do, however absurd it may be. If he is assured that simple water is some bitter and nauseating mixture, he spits it out with grimaces of disgust when he attempts to swallow it; if he is assured that what is offered to him is sweet and pleasant, though it is as bitter as wormwood, he smacks his lips as if he had tasted something pleasant; if he is told that he is taking a pinch of snuff when there is not the least particle of snuff on his finger, he sniffs it and instantly sneezes; if warned that a swarm of bees is attacking him, he is in the greatest trepidation, and acts as if he were vigorously beating them off. . . . His own name he may know and tell correctly when asked to do so, but if it is affirmed positively to be some one else's name, he believes the lie and acts accordingly; or he can be constrained to make the most absurd mistakes with regard to the identities of persons whom he knows quite well. There is scarcely an absurdity of belief or of deed to which he may not be compelled, since he is to all intents and purposes a machine moved by the suggestions of the operator." So far as this exact description goes, there would appear to be a close likeness between the French sergeant described by Dr. Mesnet and the mesmerised subject. In both the same mechanical phases are apparent, and in both the life and actions are distinctly automatic, and regulated essentially from without and at the will of the external guide and counsellor.

The natural somnambulist, in turn, closely resembles in his acts and habits the subject of the mesmerist's operations. It is a notable fact that in the scientific study of somnambulism great differences are found to exist in the relative activity of the senses. One sleep-walker may see but does not hear; a second may hear, but be blind to external impressions. In some the eyes are closed; certain objects in one case may be seen, to the exclusion of others; and one sense—most frequently, perhaps, that of touch—may become inordinately acute. Such considerations lead us towards the explanation of the remarkable dexterity with which a somnambulist will conduct himself in the most untoward and dangerous situations. Like the mesmerised subject, the sleep-walker will execute feats of strength, of manual dexterity, or of acrobatic agility, such as in his waking state he would never dream of attempting. There is present in such cases an in-

creased flow of nerve-power towards the particular sense or senses concerned in the direction of the sleep-walker. Everything that concerns other senses or matters foreign to the exact business in hand, so to speak, is excluded from the mental view. There is but one idea animating the mind, and the whole brain-force may be regarded as concentrating itself for the performance of the task in hand. The somnambulist, in short, has become a temporary specialist in the matter of his dream, and his whole frame becomes subservient to the performance of the aim unconsciously set before him. On some such principle may we account satisfactorily for the walk during a sleep-vigil along the ledges of a house-roof, and the easy access to situations of peril. Under this unwonted stimulation of a special sense or senses, the difficult problems or unsolved tasks of the day may be successfully and unconsciously achieved during the night. The history related by Abercrombie in his "Intellectual Powers" of the sleep-vigil of an eminent lawyer illustrates the latter observation. A case involving the formation of an elaborate opinion had occupied this gentleman's attention for a considerable period. Rising from his bed in a sleep-vigil he was observed by his wife to pen a long communication at a desk which stood in his bedroom, the paper being carefully deposited in the desk, and the writer returning to bed. In the morning he related to his wife the particulars of a remarkable dream he had experienced, in which a clear train of thought respecting the case in question had occurred to him. To his regret, he added, he could not recollect the details of his dream, but on being referred to his desk the opinion in question was found clearly and lucidly written out. Numerous instances of like successful solutions of intricate problems in mathematics have been placed on record, but the details teach the same lesson respecting the exaltation of mental power, stimulated probably by the efforts of the day, which may take place in the brain which retains its activity in the watches of the night.

Persons have been known actually to swim for a considerable time in the somnambulistic state without waking at the termination of their journey; others have safely descended the shaft of a mine, whilst some have ascended steep cliffs, and have returned home in safety, during a prolonged sleep-vigil. More extraordinary, perhaps, as showing the close likeness between the abnormal and automatic acts of the French sergeant with an injured brain, and the actions of the somnambulist suffering merely from functional disturbance of the organ of mind, is the case of a young French priest, related by the Archbishop of Bordeaux in the "Encyclopédie Méthodique." This subject was accustomed to pen his sermons during his sleep-vigils, and, having written a page, would read it aloud and duly correct it, even extending his alterations to include important grammatical and

rhetorical effects. A card held between his eyes and his manuscript did not interfere with his work. After a page had been written it was removed, and a blank sheet of paper of the same size laid in its place, as in the experiment on Dr. Mesnet's patient. On this blank sheet the unconscious writer made his corrections in the exact lines in which they would have appeared in his manuscript—in this latter respect imitating to the life the sergeant's procedure. In respect of his sensations, the subject of the archbishop's notice evinced a more acute disposition than Sergeant F., for his words bore only upon the subject which was engrossing his thoughts, and he heard and saw only such things as immediately concerned his work; whilst he detected the difference between brandy and water, when the latter fluid was supplied instead of the former, which he had asked for. The subjects and thoughts of one sleep-vigil were remembered during the next, but he was entirely unconscious in his waking hours of all that had taken place in his acted dreams.

It may thus be held that an injury of the brain may induce a condition closely allied in every respect to that exhibited in the natural sleep-vigil; the differences between the condition of the priest and Sergeant F. being those of degree and not of kind, and the superiority of intellect, if so we may term it, being, as might naturally have been expected, on the side of the somnambulist. The correlation of the acts of the automatic patient with those of the dreamer is too plain to be mistaken. In both cases there would seem on superficial consideration to have been a power of discerning objects and of constructing a written manuscript, well-nigh as wonderful as that of "second sight" itself. But the explanation of such conditions is to be founded upon the consideration that in somnambulism and in the automatic patient, as in abstraction, reverie, and simple dreaming, there exists the power of projecting outwardly from mind and brain a vivid conception of the object engaging the attention of the dreamer—a power intensified and accelerated, as we have already seen, by the concentration of the faculties—wholly withdrawn from the outer world—upon the one and engrossing subject of the vigil. It seems perfectly clear that, as has well been expressed, we meet in the somnambulist the actor of a dream, under conditions of mind produced by some functional disturbance of brain. In the closely allied automatic state, also, we find a condition of mind the result of direct alteration of brain-structure, in which, as in the sleep-vigil, there exists a power of the brain to guide the body in the absence of consciousness, as commonly understood—such a power being perchance merely an exaggerated form of that whereby the day-dreamer withdraws his Ego from the outer world and communes with the universe which his fancy builds.

But we may now profitably study the dream pure and simple, as a conclusion to these chronicles of the abnormal action of brain and

mind. The dream is not rigidly separated from the sleep-vigil, any more than the latter is removed from abstraction and reverie by a great gulf fixed. The transition-stage between the dream simple and the dream acted is witnessed in the spasmodic movements which a vivid dream produces in the limbs or person of the sleeper. The dreamer engages in a fierce struggle, and twitchings of his legs and arms indicate the feeble response of body to the promptings of mind removed from its wonted power over the frame. Even the dog, as he sleeps, apparently dreams of the chase, and gives vent to his sensations by the short, sharp bark, or sniffs the air, and starts in his slumber as if in response to the activity with which, in his dreaming, he is hurrying along after the object of pursuit. But whilst dreaming may thus be shown to link itself to more unusual states of mind, it also presents us with a nearer approach to those fundamental conditions which constitute the basis of all the phenomena presented to us in the physiological history of sleep. From dreams we may start, as from a common centre, to well-nigh any and every abnormal state which mind and brain in their more unusual phases of action may exhibit; whilst conversely these phases may be often traced in their broad outlines and in their undeveloped state in the dream.

To approach the understanding of the dream in a satisfactory fashion, it is necessary to remind ourselves of the ordinary methods by which sensations or impressions are received and retained by the brain. Briefly detailed, and as already hinted at in a previous portion of this paper, the organ of sense receives, modifies, and transmits to the real seat of knowledge in the brain the conception of outer things impressed upon the sensory surface—eye, ear, or touch-bodies, as the case may be. From the brain the sensation converted primarily into the consciousness and knowledge of every-day existence may be reflected over the body to muscles or other organs, and therein produces effects corresponding to the nature of the original impression, and to the demands such a sensation makes upon the body and its interests. Just as often, however, impressions may pass from the outer world into the brain, and, whilst causing molecular stirrage in the seat of mind, may give no external sign or symptom of their mental reception. Despite the want of such outward indication of the brain's response to outer stimuli, there may ensue an internal act on the part of the brain itself, by way of reaction upon the sensation it has received and registered. Thus we have opened up before us a new region for thought. As the sensation received by the brain may be reflected to the muscles and cause us to indulge in a walk or in some other form of muscular activity, so the brain may simply distribute its sensations within itself. We make acquaintance in this fashion with the doctrine of the "reflex action of the brain." Such a thought affords a clue of much value to the

knowledge of the nature of dreams and the allied states we have already considered. It is obviously not in any sense necessary that consciousness should take part in this transmission, from one part of the brain to another, of ideas and impressions. Indeed, if personal experience is appealed to, we may urge that of the mere existence of such action we are not likely to gain any knowledge from the ordinary acts and method of our waking lives. And still less is the will concerned in this reflex action of the brain. Admit that the brain may act and react upon itself, in virtue of external impressions received by it and retained within its mystic portals, and we are furnished with a key which, if it may not unlock all the secrets of the mental chamber, may nevertheless supply us with materials for a due understanding of what dreams are made of.

We have seen that the faculty of abstraction and reverie passes naturally into that of sleep, and in like manner we may suggest that the presence of such a faculty depends on this power of the brain to commune with itself which we have just been considering. Trains of thought, received casually it may be and without awaking any active mental response or the slightest glimmering of consciousness, are thus reproduced in the dream, it may be with automatic faithfulness, or on the other hand distorted beyond such recognition as we might have possessed of the original ideas. Such is the simple dream. Carried to a further extent, the dream becomes associated with action; the reflex power of the brain extends its limits; the simulation of the every-day power of calling bodily action into play takes place, and the ideas of the dream become acted. The way of the sleep-vigil is thus inaugurated and produced as a temporary phase of mental activity. Under other circumstances, it may be this reflex action of the brain will project from its memory-stores the remembered ideas of long ago or the unconscious registrations of past years; and thus the "hallucination" and "illusion" appear also as the product of the same action which, in a modified degree, produces the harmless visions of the night. Starting from the simple sensation or impression, and beginning with its reception by the brain, we have but to think of the organ of mind reacting upon itself to form a starting-point for the outlines of a complete history of all mental acts, and of our walks in those strange byways of thought and action of which mention has been made in the context.

A very few considerations of interest, as bearing on the mechanism of dreams, may be added by way of bringing this already extended paper to a close.

Recent investigations into the functions of the brain point to the *central ganglia*, or those nervous masses (*corpus striatum* and *optic thalamus*) lying on the base of the brain, as the probable seat of the actions we have just been considering. These particular brain-

ganglia appear to possess the direct function of converting intellectual operations into automatic actions. Thus the musical composition which at first requires the concentrated effort of mind to master it, may in a few days be "played off." The latter accomplishment is due to the "central ganglia," which, acting as private secretaries to the purely intellectual (and frontal) portion of the brain, have reproduced automatically what at first was an intellectual act and one demanding an exercise of attention and mental effort. The action of these ganglia in the production of dreams and somnambulism is readily understood, when we thus become aware of the facts that all parts of the brain do not possess the same intellectual value, and that these central masses are capable of forming reproductions and imitations of our waking lives, during the hours of sleep. In sleep, or it may be in illness or after injury, these lower brain-centres, in a word, assume the functions of higher centres, and play strange pranks with the rational slumbering existence, or with the waking but abnormal life of the diseased brain.

Various distinguished writers remarking on the phenomena of dreaming agree in affirming that the thoughts of our sleeping hours must invariably bear some defined relation to the antecedent thoughts and events of our lives—it may be to the acts of the previous day; or, on the other hand, to ideas separated from our last waking moments by an interval whose years make up the best part of a life's duration. To say that dreams may deal with subjects of which we have never had any knowledge whatever is to suggest the indefensible proposition that we can and do remember all the events and ideas which have occurred and been present with us during our entire existence, or, in one word, that memory is practically omniscient and infallible; whilst against the idea just noted we must place the opposing thought, that the brain's action being largely unconscious in the common operations of receiving, and certainly in those of registering and preserving, impressions, it is more logical to conclude that dreams usually represent images and conceptions of material things—these material ideas or events being often indistinctly presented, frequently altered and transmogrified in their reproduction, and commonly projected within the range of our night-thoughts in a fashion which may defy our recognition and comparison of them as parts of the waking-life of former days. There is no lack of proof from many sides of the extreme probability that these assumptions represent the whole or the greater part of the truth about dreams. That the event suggesting a dream is one which may cause us some trouble in identifying it with our distorted visions is easy of proof from the side of practical experience. Impressions on some special sense will produce very characteristic dreams, the origin of which may take such trouble in its determination that we might well

be tempted to deny the material origin of the vision Dr. Reid had a blister applied to his head, and dreamt accordingly that he had been scalped by Indians. Here the connection between the dream and the outward impression, manipulated so to speak by the brain, was clear. But that connection may be anything but patent in cases where a person dreams of being frozen to death, the exciting cause having been merely a deficiency of bedclothes on a chilly night. In a case related by Dr. Carpenter, where an eminent judge dreamt of being tormented by a crowd of lizards which were crawling over him, the origin of the dream was still more difficult to trace. The cause of his reptilian visitation was readily explicable, however, on his entering the apartment in which he had spent the previous evening, when he saw on the base of a clock a number of carved lizards. A similar instance is afforded by a personal experience of the writer, in which he dreamt that he was walking in a forest in which lizards of every hue and kind were engaged in a combat with humming-birds. Puzzling himself over the origin of this dream, it at last dawned upon his recollection that some time previously he had travelled in a railway-carriage having for his *vis-à-vis* a lady whose hat was decorated with humming-birds' plumage, fastened by a brooch accurately representing a lizard. By the same kind of association revived by memory, and often projecting forgotten reminiscences into the mental foreground, dreams are suggested which deal with events at first sight apt to be mistaken for those of utterly spontaneous nature. Maury relates that in early life he visited a village on the Marne named Trilport. His father had built a bridge at this spot. The subject of one dream was that his childhood days were again being spent at Trilport, and that a man in uniform, on being asked his name, told Maury that he was the bridge gate-keeper and mentioned his name, which Maury distinctly remembered when he woke. Of this name he had no recollection whatever, but on inquiring of an old servant of his father's if a person of the name in question was once gate-keeper at Trilport bridge, she replied in the affirmative, and mentioned that the man kept the gate when the bridge was built.

Thus does memory play strange tricks with our imagination, especially when the latter faculty runs riot in the absence of will and consciousness, and relates itself to the world of dreams. The supernatural theory of dreams and warnings recently revived in our midst is, after all, but a sop to the Cerberus of ignorance. It is easy—far too easy for the peace and comfort of many minds—to convert a mere coincidence between a dream and an event into a close relationship which sees in the dream a foreshadowing of the event in question. But in science, as in healthy common-sense, there is no justification for the continuance of such superstition. If certain dreams are warnings and portents, what shall we say of those to which no such

function can be attached? And if of certain trivial events we are forewarned, what is the explanation of the striking anomaly, that of the grave disasters of life we usually receive no warning at all?

Dr. Maudsley says, "It has been justly remarked that if we were actually to do in sleep all the strange things which we dream we do, it would be necessary to put every man in restraint before he went to bed; for, as Cicero said, dreamers would do more strange things than madmen. A dream put into action must indeed look very much like insanity (*e.g.* the ordinary sleep-vigil), as insanity has at times the look of a waking dream."

Poets without number have invariably treated dreams as the best type of the unrealities and idealities of life and nature. The physiologist, on the contrary, sees in the visions of the night no trifling objects unworthy of serious study and reflection, but indications and clues to the better understanding of the mysteries which beset our waking lives. "The grave portents" of the night, in this view, cast no shadow over the future, and exercise no sway over the destinies of the modern mind. They serve, however, a nobler purpose, as aids, through their revelations of the leisure-fancies of the brain, towards a knowledge of the boundaries which separate the realm of body from that of mind—boundaries which, in truth, "divide our being."

XIV.

COINAGES OF THE BRAIN.

THE means whereby we are enabled to form conceptions and judgments of the outer world, and of our own relations thereto, form the subject-matter of the most elementary study in the physiology of nerves. But as the understanding of the deepest problems often depends on the correctness of our primitive studies and on the soundness of the beginnings of knowledge, it may be well that, in studying the work of the brain, we should very briefly glance at the manner and method in which body or outer world usually acts upon mind, and mind in turn upon the frame it controls. Such a simple study in sensation will suffice to introduce us to some interesting phenomena of mind; and these last may prove of some service, even if they may but aid us in some degree to comprehend the nature and ways of our own being.

When, under ordinary circumstances, an impression from the external world reaches the outward parts of our nervous system, or passes through one of those "gateways of knowledge" which we term an organ of sense, it is transmitted in due course to a special part of the nervous system named a nerve-centre. There the impression gives rise to actions or processes which result in the production of a "sensation," and commonly also of "consciousness"—that is, the knowledge of the why and wherefore of our acts and feelings. Apart from metaphysical vagaries and subtleties, this much seems clear—that any simple sensation, starting like an electric current from the outer world, and passing along the wires we term nerves, to the head-office or brain, gives rise therein to responsive feelings, and, it may be, to corresponding and related actions in the body as well.

Example is more potent than precept; let us therefore turn to the study of a common sensation such as that of touch, by way of illustrating the ways and methods of the ordinary government of life. A person aims a blow at our head, and that important region is quickly, and we may add automatically, withdrawn from the threatened contact with the malcontent. The explanation of our action is perfectly clear. The impression of the moving fist was caught by the eye, was modified by its passage in the form of light-rays through that organ, was converted into a "sensation," was transmitted through a special (optic) nerve to the brain, was therein transferred to some special region of the seat of mind, and finally gave rise to the

"consciousness" or thought of the danger which threatened our person.

Now, all of these actions took place so quickly that their accurate analysis might well seem to be impossible. Still, the sequence of events proves the accuracy of the statement that the seat of knowledge, and in this case the power of acting or walking by sight, is resident in some part of the brain, to which it is the function of the eye and optic nerve together to convey the impressions and sensations on which our knowledge depends. But the effects of the threatened blow end not thus with the declaration of "information received" emanating from the brain. Like an active and efficient official, the brain is prone to act upon such intelligence. The head is withdrawn from the blow, the body itself is removed, it may be some paces backward; and unless discretion be deemed the better moiety of valour, there may be responsive and co-ordinated muscular actions of hands, arms, and possibly of legs or feet as well, wherewith swift and sure retaliation may be made upon the sensiferous organs and most tangent regions of our antagonist. In other words, if an impression has been received *by* the brain, it is no less plain that another—or it may be several impressions have issued *from* the seat of mind. These have radiated, as directed by the brain, to the muscles of our head and neck, and to those of our limbs; and our subsequent movements are the result of this secondary brain-act which follows upon the reception of the previous impression. Thus we begin to understand that, in their nature, ordinary nervous acts are really double, and that all our ordinary acts and our extraordinary actions as well are regulated by a kind of duplex telegraphy on the part of the nervous system. It also becomes apparent that even the confused heat and bustle of a severe scrimmage—or the whirling maze of heads, hats, and coat-tails which are popularly believed to constitute an enlivening feature of festivals of which Donnybrook remains the type—may, through a patient scientific enquiry, be resolved into so many sensations received and acted upon through the system of mind-telegraphy just described.

It remains, therefore, a plain doctrine of modern physiology that our knowledge of the outer world is received and acted upon through a very definite system of actions and reactions. True, we do not know what constitutes an impression. We have measured the rate at which nerve-force travels, but the exact nature of this force is unknown. Consciousness—and the reception of impressions by the brain—has not advanced materially in explanation since Hartley, in his "Observations on Man," spoke of the "vibrations of the small, and, as we may say, infinitesimal medullary particles," which he conceived further to be "motions backwards and forwards of the small particles" of the brain, and to present a similarity to "the oscilla-

tions of pendulums, and the tremblings of the particles of sounding bodies." And of what takes place in the brain when the impression from the outer world is converted into that proceeding from brain to body and to the outer world again, we are likewise in the depths of ignorance. But despite our inability to read between the lines of the brain-work, the general nature of nerve-action remains as a clear and patent basis for further research. Nervous acts are now spoken of in physiology as being founded on the grand principle of "reflex action," with the name of which every schoolboy is familiarised by his physiology-primer. The ordinary acts of living and being are regulated on this duplex system. An impression (which we call *afferent* or *sensory*) travels inward to the brain or other centre, and is there converted into another impulse (named *efferent* or *motor*), which passes outwards to muscles, to glands, to other organs, or it may be to some other part of the brain itself. The original impression or sensation is thus "reflected," as it were, from a nerve-centre to some other organ or part. The sensation of withdrawal from danger, to which the threatened blow gives rise in the brain, was duly "reflected," and thus passed onwards to the head and neck-muscles, and, in the case of practical retaliation, to the muscles of the limbs. So that, in this view of matters, the brain may be regarded as largely performing the functions of a complex "clearing-house," where the varied business-concerns of the frame are assorted, parcelled out, rearranged, and finally transmitted to their proper destinations.

Other examples of this duplex system, and of the power of the head-centre of the nervous system to receive and retransfer impressions and sensations, may throw a further light upon some special features and noteworthy characteristics of its action. Select, for instance, the sensation of touch, and we shall have forcibly impressed upon our understanding the fact that the brain or sensorium is the true and actual seat of knowledge. This latter truism, plain as it may appear, is not usually appreciated until the attention has been directly called thereto. It is needful, in truth, for the correct understanding of the evolution of mind-phantasies and illusions, that such a truth should be continually present in all its plainness to the mind. We touch a table, and the *rationale* of the nervous acts therein implied is readily explained. Thought—laying aside the question of antecedent conditions and influences—begins the act, and determines the desire to touch the object. This thought next becomes transformed into nerve-force—how, why, when, where, are details all-important in their profundity, but immaterial to the plain issue before us. This nerve-force passes, under the direction of the brain, along definite nerve-tracts, leading, say, to the forefinger of the right hand. On the way, it stimulates the appropriate muscles. Thus the finger is brought in contact with that part of the outer world repre-

sented by the table, and a "sensation" (of touch) is the result of the contact in question. Here ends the act, we may be disposed to say; but our previous knowledge of "reflex action" and its nature forbids the supposition. "How do you know you touched the table?" is the pertinent query of physiology. The reply is, "Because I felt the contact betwixt my nerves and the object in question." But, retorts the physiologist, "feeling is a brain act; it is an act wherein consciousness or knowledge participates. The seat of knowledge is not the tip of the finger, but the brain. And you must therefore reasonably assume that to the brain the sensation formed and produced in the forefinger is transmitted." Thus we find logical justification for the doctrine of "reflex action," in a common-sense study of the results of touch. The motor impulse sent out from the brain, and, putting the arm and hand in motion, is returned to the brain. It is "reflected" back as a sensory impulse to the sensorium, and kindles therein the knowledge we desire even whilst we are yet in mere expectancy.

But is this induction founded upon anything more than a consistent theory of brain control and bodily action? In 1811 Sir Charles Bell published his first essay on the nerves which originate from the spinal cord (hence called "spinal nerves") and which supply the body generally with nervous power. The spinal cord itself being a direct continuation downwards of the brain, it follows that impulses from the brain pass at first along the main line of the spinal marrow—lodged securely within the bony canal formed by the spine—and thereafter pass along the nerves or branch lines to various stations and termini in the body. To Sir Charles Bell belongs the great and lasting merit of the discovery of the difference in function between the two roots by which each spinal nerve arises from the spinal cord. Each nerve passing outwards to the body, thus consists in reality of two sets of nerve-fibres, indistinguishable by microscopic investigation, similar in appearance, but widely different in use and function. Once for all settling, by vivisection on rabbits, the meaning of the double-rooted origin of the nerves, Bell laid the foundation of all subsequent knowledge of nerves and their functions to which in these latter days we have attained. "On laying bare the roots of the spinal nerves," says Bell, "I found I could cut across the posterior fasciculus (or hinder root) of nerves, which took its origin from the posterior portion of the spinal marrow, without convulsing the muscles of the back; but that, on touching the anterior fasciculus (or front root) with the point of the knife, the muscles of the back were immediately convulsed." Thus was foreshadowed the great truth that those fibres of a nerve which arise from the hinder part of the spinal cord endow us with sensation; whilst the front roots give us power of motion. Turn now to

the phenomena of touch, and let us endeavour to see how Bell's observation supplies the demonstration of the reflex or duplex theory of nervous acts. When the impression which resulted in your touching the table flashed down the spinal cord from your brain, it was a *motor* impulse. As such, its definite track lay along the anterior part of the spinal cord. It left the cord by the front roots of the nerve-trunk passing to the arm; and travelled along these anterior fibres which unite with the fibres of the hinder root to form apparently a uniform and single-fibred nerve. Reaching the limb, the motor impression arrived at its terminus, and discharged its duty by bringing the muscular arrangements of arm and hand into co-ordination, and thus bringing finger and table into contact. A "sensation" was thus brought into existence, but this latter impression—probably consisting of the transformed "motor" impulse which the instant before had travelled down the limb—passed rapidly backwards to the brain as a *sensory* impression. Along the second set of fibres in the nerves of the limb it was duly conveyed. Arriving at the grand junction where the branch nerve from the arm joined the main line of the spinal cord, the impression passed along the hinder root of the nerve into the cord, and ascended to the brain by the hinder part of the great nerve-tract. In the brain-centre, the "sensation" gave rise to consciousness and knowledge; and thus "reflex action" becomes demonstrated as a veritable entity and as the method whereby the complex machinery of body is brought into harmonious relation with the still more intricate mechanism of brain and mind.

Next in order, and by way of close to these preliminary studies in sensation, we should note that it is perfectly immaterial, in so far as the universality of reflex action as the basis of nervous acts is concerned, whether the original or primary impulse begins in the brain as the result of thought, or arises directly from the outer world itself; that is, it matters not whether the first impulse or sensation be "motor" or "sensory" in its nature—the same sequence essentially follows the initiation of any nervous action. The "mouth waters" at the sight of a dainty—proportionately, in the experience of most of us, as the chances of obtaining the desired morsel grow few and far between. Here a sensory impulse has passed to the brain through a nerve (the optic) which happens to be of purely sensory kind. In the brain the sensation, or sensory impulse, has been transformed into an afferent impulse—termed "secretory" in this instance, because it is reflected to the salivary glands of the mouth, with the familiar result just detailed of causing them to secrete their characteristic fluid. In this case the "sensory" impulse therefore begins the reflex act; whilst in the case of touching the table it is a "motor" impulse which first leaves the brain, and which is soon

converted into a sensory impression ending in consciousness or knowledge. Equally important is the question, how does the brain regulate the direction and transmission of the messages innumerable which hour by hour flit in and out of its portals? To such a query no answer is possible. Why or how we are able to move this finger or that, how we can lift this limb or the other, is a mystery of mysteries in modern physiology, dwelling as yet in the farthest Arcanum of the science. Lord Dundreary's question, "why a dog wags his tail," if placed in contrast to his lordship's companion and equally grave query, "why does the tail not waggle the dog?" in reality involves a physiological enigma of which not even the shadow of a reply is yet visible. All that may be said on this head is, that the brain must possess amongst its other attributes the pointsman-like power of directing nerve-impulses into whatever channels the will and mind may prompt. Thus the physiological mystery of the will is as deep and insoluble, at present, as the metaphysical or theological aspects of the question; and thus appears before us a puzzle exceeding that of the Sphinx in its gravity—in plain language, we are unable to tell the reason why we are able to do as we like.

Summing up the few details we have gleaned in our elementary but highly essential study of the broad mechanism of nerves and brain, we may thus learn to distinguish between sensory and motor impressions and between the nerve-fibres along which each is conveyed. We note the power of the brain to reflect, rearrange, and transmit such impulses as reach its substance. We have seen that reflex action in reality forms the basis of our own life and habits, and by a further extension of thought we may note the part it plays in the life of all other beings. When a snail's tentacle is touched, that modest gasteropod withdraws itself from public observation, and retires at once into the quietude of private life. Reflex action, which has transmitted the sensation of touch to the nearest nerve-centre and thence to the muscles of the body, is clearly responsible for the behaviour of the mollusc. Even a sea-anemone captures the crab that has stumbled against its tentacles by a like or allied exercise of nerve-acts; and the sensitive plant, and Venus' Flytrap, exhibit the essential features of nerve action in that information received is transmitted elsewhere through the organism, and reacts upon the life and existence of the plant.

For the due performance of reflex action three things are required. First in point of importance comes a nerve-centre; next in importance we place a sensory, and then a motor nerve-fibre, leading respectively to and from the nerve-centre. Concerning the nerve-centre we have hitherto spoken as if the brain were the sole representative of the chief office of the telegraphic system of the frame. Be it known, however, that whilst the brain is such a centre, or rather collection

of centres and chief departments, there exist in the body numerous other foci, so to speak, whence impressions may be reflected and rearranged. Next in importance to the brain, we find the spinal cord to act as a nerve-centre; and it is perhaps the only focus of nerve power, in addition to the brain, of which special mention need be made at present. One observes how the cord may serve as a centre in those too frequent cases of shock to the spine seen after railway accidents and similar exigencies of life. The patient with a severely injured cord is practically dead to sensation below the seat of injury, is powerless to move his legs, and yet will have his limbs thrown into violent convulsions when the soles of his feet are tickled. Over this latter action he has no control, just as he has no knowledge of the irritating cause beyond what his eyes reveal. Yet the explanation is clear. The sensory impulse given to the soles of the feet passes up the spinal cord to the nearest centre in the cord below the seat of injury, and is therefrom reflected to the muscles of the legs, producing the contortions in question. And more wonderful still is the case of that physiologically useful animal the frog, which, lacking its head, behaves itself as does a whole and sound amphibian; wipes off with one foot a drop of vinegar which has been placed on the other; manœuvres its legs when in a difficulty regarding the removal of the vinegar; keeps its balance on your shifting hand; preserves its equilibrium with the agility of an acrobat; and otherwise comports itself in a fashion which strikes awe to the uninitiated mind, but which demonstrates clearly enough the functions of the spinal cord as a nerve-centre to the physiological understanding.

From the study of the mechanism of sensations in general we may profitably turn to that of sensations in particular, wherein we shall find our elementary knowledge not merely an aid, but an absolute essential, towards a clear appreciation of the unusual and strange as well as of the familiar in human existence. The thoughts and concepts we entertain of the world around us may be regarded as the impressions, more or less thoroughly fixed, of sensations which have been conveyed to us by many and varied channels from that outer universe. How the impressions became fixed, or how we are enabled to reproduce them almost at will from the memory-chambers of the brain, are subjects which may perchance be briefly glanced at later on. Suffice it to remark that knowledge largely, if not completely, consists in a physiological sense of "registered impressions," which have become, in some mysterious fashion, part and parcel of the cerebral substance, and which have been stamped more or less indelibly on the organ of mind. "The coinage of the brain," in very truth, derives its rough form and shape from the outer universe; it is the brain itself which thereafter stamps and issues the refined products as the thoughts of men. These thoughts thus

arise wholly or in greater part from impressions, which, being derived directly or indirectly from the objects and material world around us, we may term *objective* sensations. They consist of the mental photographs of the outer world, of ourselves, and of our own relations to the world, which have been projected inwards so to speak, and there fixed, to be printed off, as occasion requires, for future use. The effort to recall reminiscences of past life and the ineffective search after memories may be readily enough likened—to pursue the same simile—to the attempts of the mental photographer to find amidst his many negatives the particular one required by the exigency of the moment. Now and then we give up the quest in despair; but just as frequently, at a time when the necessity for the remembrance of the event has passed by, there dawns upon us the missing recollection—the reproduction, by some sudden and inexplicable trait of mind-photography, of the mental positive, printed off from its stored-up and long-hidden facsimile. I should maintain, indeed, as a plausible enough theory of the memory-faculty and its action, that no mental concept is ever lost entirely. Crowded out of mind by the thoughts of later years, impressions of youth may nevertheless be suddenly resuscitated by a chance word or a passing glance. And often unconsciously to ourselves, and in ways defying logical conception, we may thus build veritable "haunted houses," wherein the phantoms that rise and walk and converse are not of flesh and blood, but represent the figures, ways, and even speech of those whose life is buried in the past, and whose time was that of the long ago.

That, however, this memory-power of projecting from within outwards, upon the intelligence, impressions, and sensations—either of real nature, or blurred and indistinct from causes beyond our ken—possesses a further significance than merely that attaching to a feasible speculation in physiology, may readily enough be made plain. We sit down in some quiet nook on a still day, when hardly a sound may be heard, and when the voices of the outer world appear to be well-nigh hushed to silence; and, favoured by outward conditions, we fall into a reverie. Abstracted from that outer world, image after image is projected from within outwards upon our intelligence, which occasionally may actually fancy it sees vividly the objects it displays, or that it hears the sounds which old memories so clearly bring before it. A tune hummed softly awakens a thousand memories; the singer of olden days comes before us in all the reality of existence; the surroundings are reproduced with faithful exactitude; the most trifling detail comes boldly into the foreground of thought; a ribbon, a bracelet, the pattern of a carpet, the hue of a dress—these and a thousand other details are pictured out with truest fidelity; and the story is acted before our eyes so faithfully, that it is with a start of

wonderment we suddenly come back to the workaday world, to find "it was but a waking dream."

Nor can we refuse to consider the influence of repetition and habit as a predominating cause of such abstraction and reveries. Who does not know the "dreamer" of everyday life, or it may be the poet or poetaster, wrapt in a mantle of thought which defies the penetration of mundane things, and within which he sees and hears a universe of his own? A near gradation, however, brings us within range of the "hallucination" and "illusion," where the creatures and coinages of the brain are projected with more marked effect and in bolder relief than before. Now it is Satan tempting a Luther—a very devil in the flesh, with whom the religionist converses and argues, whom he defies loudly and persistently, and at whose head the irate reformer throws his ink-horn—a proceeding typical, indeed, of the extinction of many demons by the sweetness and light of pencil and pen. Then it may be a St. Anthony struggling with an evil spirit of sensuality, or with actual demons who chastise him cruelly. Or it is Joan of Arc who is admonished by "Our Lady of Bellemont" to succour her country, and to take to arms for its defence; or it is the Hindu, prostrate in pious ecstasy before the shrine of Brahmah, his visions, realities, and his fancied converse with the Almighty One transformed thus into a dread reality.

Such were the hallucinations of the age of Faith. But they have not ceased in our own day. The religionist before whom the saintly image moves, to whom it speaks, is a reality of the age we live in, no less than is the insane being we seclude in our asylum. In truth, the study of the former is as much a matter of interest as that of the insane; because, under certain phases of mind, the illusion or hallucination of the one may become the mental disease of the other. Thus it is plain that, given abstraction of thought and imaginative play, and we may evolve from our inner consciousness that poetic fervour which

> bodies forth
> The forms of things unknown—

or we may revel, by a further development of the same faculty, in the wildest dreams which ever peopled the fancies of an excited visionary, or entranced the tottering intellect of the really insane.

It is, however, necessary that we should distinguish between an "illusion" and an "hallucination"; since, although both are stages and gradations in the same series of mental actions, the moral and actual significance of the one may be widely different from that of the other. Under the general name of "hallucination," some authorities include every mental phase or act which is founded upon abnormal brain-action, and which tends to land its possessor and

subject on the shores and amid the quicksands of the unreal. Dr. Tanner, in his careful general summary of insanity and its conditions, distinguishes thus between an "hallucination" and a "delusion": "Almost every insane patient labours under hallucinations of one or more of the senses—he sees or converses with imaginary beings. When he is satisfied by the evidence of his other senses that what he sees and hears is only an *illusion*, he is said to labour under an *hallucination*; whereas, when he believes in his false perceptions, the hallucination becomes a delusion." The objection to Dr. Tanner's definition is, that he starts apparently with the assumption that all persons who suffer from illusions and hallucinations are necessarily insane. The difference, however, between the two latter conditions of mind is clearly and distinctly inferred in the definition just recorded. An "illusion" may best be defined as a disturbed state of the mental faculties, wherein the subject, sooner or later coming to test his thoughts and impressions "by the evidences of his other senses," determines that these impressions are unreal. The "hallucination," on the contrary, is not so corrected, and the belief in the appearances seen or heard being sustained, the hallucination deepens and merges into the "delusion." An "illusion" as above defined, therefore, does not include or imply insanity. The very fact that the powers of reason are brought into play to correct the phantasies of the mind places the illusion beyond the sphere of the *maison de santé*. Hence Dr. Tanner may be held to correct the impression which his own words are calculated to convey when he says, "Illusions are frequently observed in a state of mental health, being thus corrected by the reason."

But over definitions, save for the purpose of defining the use of the terms in question, it is needless to delay. Suffice it to remark that the two may gradually be merged together, just as the "hallucination" in its defined place may be said to link the "illusion" of the sane with the mad thoughts, delusions, and visions of the really insane. With the explanation of the latter we have nothing at present to do. The person who wrote to Dr. Conolly, demanding "A Holy Bible with engravings, &c., a Concordance, a Martyrology with plates, some other religious books, a late Geographical Grammar, a Modern Gazetteer, newspapers, magazines, almanacks, &c., of any kind or date; musical instruments and music; large plans, guides, maps, directories," and many other works; ending his epistle with a demand for "wines, fruit, lozenges, tobacco, snuff, oysters, money—everything fitting to Almighty God," and who concluded his letter with the remark, "Answer this in three days, or you go to hell. P.S.—A portable desk and stationery, and a dressing-case"—such a correspondent—a monomaniac—no doubt suffered from hallucinations, but of a type in which they had become

the delusions of a hopeless case of insanity. On the other hand, the sane man who sees and hears things he knows to be nonentities and to represent merely the coinages of his brain, despite their vividness and apparent reality, is a subject of physiological and not of medical study; and the brief chronicle of such a history enables us also to explain scientifically the visions of the ghost-seer, and the beatific spectacles which greet the exalted senses of the religious devotee.

Through our study of sensation and its *rationale* we saw that mental conceptions of outside objects, or of external sounds and other material phenomena, were carried inwards to the brain and there stored up for future use. We have likewise seen that in a day-dream this formation of mental images—or of *objective sensations*, as we termed them—appears to be superseded by another class of sensations which may be appropriately named *subjective*, since they are produced by internal causes, by inward phases of mental action, and are thus opposed to those sensations which are derived from the outer world. Just as in ordinary nervous action the brain receiving, as we have seen, an impression from the outer world, transfers that impulse elsewhere, so we may conceive that sensations and ideas which pass to the brain as a terminus may be reflected and returned along the pathway by which they entered the kingdom of mind, and thus give rise to impressions of the "subjective" class. Or, to quote Fiske's happy remark, "Consciousness has a foreground as well as a background." On the clear appreciation of this simple fact hangs the explanation of a very grave and complex theme: for the illusions of the visionary, and the waking dreams of the seer, are scientifically explicable on the supposition of their "subjective" character. On the belief that they represent images reflected outwardly from the brain upon the organs of sense, we may well understand how things not seen normally become realities to those who see them from within.

Every day may be said to bring to the healthy mind practical instances of the occurrence of subjective sensations, such as in more typical development constitute the "illusions" of the curious. To select an example within the practical reach of all who may be disposed to try the experiment, suppose we allow the head to depend for some time as in the stooping posture, we hear noises in the ears, sounds of "singing" or "ringing," as we popularly term them; flashes of light before the eyes—also beheld in cases of direct irritation of the organ of sight—and we may also experience a variety of other sensations which are truly "subjective," in that they are produced by no outward noises or sights, but by an internal cause, most probably temporary congestion of the nerve-centres. That there should exist a perfectly natural tendency to speak of the phenomena just mentioned as "heard" and "seen" respectively is a

matter exciting no comment. We continually refer to the outward and usual sources of sensations, the impressions which may actually be produced from within. The effect of this perfectly natural method of discerning the origin of sensations becomes ludicrous in practice when, through surgical circumstances over which the patient has no control, a change of locality befalls the nerves in question. A subjective sensation, for instance, refers pain at the extremity of a stump to the portion of the limb which has been removed. A patient who possesses no leg may thus feel pain in his toes. More curious still are the results of the Taliacotian operation for the restoration of the nose. In such a procedure, a flap of skin is detached from the forehead and folded down so as to form the new olfactory organ. So long as the flap remains connected with the forehead, so long will the patient refer his sensations to the forehead when the new nose is touched. That "things are not what they seem" may thus be illustrated physiologically in a very perfect fashion. Subjective sensation here refers the impression to the original seat of the skin—namely, the forehead—although in time the nose-flap adjusts its sensibility to its new position. So, also, in the well-known experiment of crossing the fore and middle fingers and feeling the tip of the nose with the crossed digits, the organ of smell appears double. Here the surfaces of touch being altered and transposed, the double sensation or illusion arises from the mind referring the impression received by each finger to the natural and separate position of the digits.

Still more remarkable are certain subjective sensations produced by a potent belief in the existence of the conditions which give rise to actual (or objective) sensations of like kind. The late Professor Bennett of Edinburgh relates a case in which a procurator fiscal, or public prosecutor, in Scotland attended the exhumation of a body in a case of supposed murder, and had to withdraw from the scene on account, as he alleged, of the overpowering odour attending the procedure, and emitted, as he believed, by the coffin. On the latter being examined, it was found to be empty! Another case illustrates, in an equally interesting fashion, the ideational and internal origin of sensations through an intense belief in the real nature of the external conditions which ordinarily produce them. An Edinburgh butcher, engaged in placing a heavy joint of meat on a hook situated above his head, slipped so that the hook appeared to penetrate his arm and to suspend him thereby. Carried into a druggist's shop close at hand, he was pale, well-nigh pulseless, and suffering, as he said, acute agony, which was intensified on the arm being moved. When, however, the arm was examined, not a trace of injury was to be observed. The hook had merely penetrated the sleeve of his coat;

yet his subjective sensations referring the injury to his arm were so real that the pallor and shock were as typically represented as if he had really been transfixed.

A still more remarkable instance of the paramount influence of subjective sensation in determining effects which would result from real or objective impressions is witnessed in the death of the surgical patient from fright as he lay on the operating-table, when Mr. Liston had merely happened to trace the line of incision with his finger. And the imaginative person who in the early days of plate-glass windows caught a severe cold from sitting, as he thought, at an open window—his eye being deceived by the want of divisions in the glass—likewise illustrated the power of subjective impressions.

From the normal creations of the brain in healthy existence we pass by a gradual transition to those cases of subjective sensations which appear as the result of some abnormal action of the brain, and which therefore bring us to the borderland or neutral territory between the domain of the sane and that of the insane. The sense which appears to be most frequently subject to illusions or subjective sensations is that of hearing. That actual injury will produce specific derangement of this and other senses is a perfectly well-known fact of physiology. A person, after a fall from his horse in which he had sustained some brain-injury, was conscious until his death—which occurred some years thereafter—of a bad odour. In another case of similar nature, one of the membranes of the brain was found diseased after death. Dr. Maudsley tells us in his "Pathology of Mind" of an old gentleman "who, perfectly intelligent in other respects, believed that offensive odours emanated from his body to such a degree as to cause great distress to all who were brought near him in his business, which," adds the author, "he nevertheless conducted with skill and judgment." This person declared that his next-door neighbours were greatly annoyed, and that even cab-horses suffered from his presence. He slept so many hours in one room, changing his bedroom during the night to avoid the concentration of the poisonous odour; yet during this period his business-partner had not observed any one irrational feature in his conduct. Ultimately he recovered from a somewhat serious illness, with the result of being at the same time cured of his illusion.

The well-known historical case of Nicolai, the Academician and bookseller of Berlin, read by himself before the Royal Society of that city in 1799, presents us with a most typical instance of the apparent reality of subjective sensations, arising from some alienation of the sense of sight. After a period of mental disquietude consequent upon a quarrel, Nicolai began to see various figures which he was conscious were but illusory in nature. There appeared to him the figure of a deceased person, which stood about ten yards off,

and remained for about eight minutes. The apparition was unseen by his wife, to whom Nicolai appealed, and in about two hours after the first phantom had appeared it was succeeded by several others. Becoming accustomed to the incident, and recovering from the natural surprise at their appearance, Nicolai set himself to examine these new and unwonted incidents of his life, but failed to associate it with any known cause or condition. When he passed into an adjoining room, the first figure which had appeared, followed him. After a day or so had passed, this first figure was succeeded by others, amongst whom friends and strangers were commingled. His intimate friends and associates but rarely appeared in the phantom crowd. His sensations may best be understood from his own words—"After I had recovered from the first impression of terror, I never felt myself particularly agitated by these apparitions, as I considered them to be what they really were—the extraordinary consequences of indisposition; on the contrary, I endeavoured as much as possible to preserve my composure of mind, that I might remain distinctly conscious of what passed within me." There was no connection betwixt the phantoms and his thoughts; nor, as he tells us, could he produce at will spectral representatives of his friends. "I tried," said Nicolai, "to reproduce at will the persons of my acquaintance by an intense objectivity of their image; but although I saw distinctly in my mind two or three of them, I could not succeed in causing the interior image to become exterior." Neither solitude nor the presence of company affected the distinctness of the images. By day and by night they were equally discernible to Nicolai, and at home and abroad they appeared to his mental gaze, whilst the act of closing the eyes had no constant effect in causing their disappearance. Although resembling real figures, he had no difficulty in distinguishing them from living persons; and although mixing with one another, the phantoms did not appear to be of a social or communicative disposition.

In about four weeks after their first appearance, says Nicolai, "the number of these apparitions increased; I began to hear them speak; sometimes they spoke to each other, generally to me. Their discourse was agreeable and short. Occasionally I took them for sensible and tender friends of both sexes, who strove to soften my grief: their consolatory speeches being in general addressed to me when I was alone. These consolatory addresses consisted sometimes of abrupt phrases, and at other times they were regularly executed. Although my mind and body were at this period in a sound state, and the spectres had become so familiar to me that they did not cause me the least annoyance, I sought by suitable means to rid myself of them.[1] An application of leeches was made to my head

[1] Nicolai, it may be mentioned, had neglected to undergo the periodical blood-

one morning (April 20th, 1791) at eleven o'clock. The surgeon was alone with me," continues Nicolai; "during the operation the room was filled with human figures of every kind: this hallucination continued without interruption till half-past four, when I perceived that the motion of the phantoms became slower. Soon afterwards they began to grow pale, and at seven o'clock they had all a whitish appearance; their movements were slow, but their forms still distinct. By degrees they became vaporous, and appeared to mix with the air, although some of their parts remained very visible for some time. About eight o'clock they were all gone, since which time I have seen nothing of them, although I have thought more than once they were about to appear."

This interesting recital affords us not only a very typical case of spectral illusions, but suggests from certain of its details the influence of continuance and habit in intensifying the appearances presented by the phantom array. At first the spectres preserved the usual ghostly silence; and in about a month after their first appearance Nicolai began to hear them speak, whilst they increased in number as time advanced. These two latter phases of Nicolai's case are highly instructive. They tend to prove, firstly, that subjective sensations, like normal or objective impressions, increase in number and distinctness with use and habit; and they show, in the second place, that a continuance of the sensations developed their complexity and intensified the reality of the creatures of Nicolai's brain. The apparent addition of speech on the part of the phantoms, and the illusion of words, clearly showed that the affection had become one of subjective hearing, as well as of subjective sight. And thus illusions exhibit a tendency to develop or to disappear like aberrations of bodily functions; whilst the course and nature of these "troubles of the brain," as a rule, are in perfect harmony with the spirit of the age, with the special proclivities of the subject, and with the times in which the sufferer lives—two facts to which may be added a third, namely, the palpable influence of habits of body or mind—such as religious fervour and belief—upon the production and nature of the illusions in question.

The case of a Mrs. A., related by Sir David Brewster, is as typical as that of Nicolai, in its description of the development of these "coinages of the brain." On December 21, 1830, this lady was startled to hear her husband's voice calling to her. After opening every door in the neighbourhood of the hall in which she was standing, she concluded that Mr. A. must have departed from the

letting in which our great-grandfathers and the succeeding generation indulged in spring-time, on some curious and mistaken popular notion (probably founded upon the periodic revival of nature and the returning growth of plants) that local depletion was necessary for the preservation of health.

house, but was more than surprised to find, on Mr. A.'s return home, that he had not been near the house on the occasion referred to. Some days thereafter, on entering the drawing-room which she had left a few minutes before, she saw Mr. A. standing with his back to the fire. On asking him why he had returned so soon from his walk, the figure looked fixedly at her, but did not speak. Thereupon, thinking her husband involved in thought, she sat down in an arm-chair close by, with the remark, "Why don't you speak?" Thereupon the figure passed towards a window at the farther end of the room, still gazing upon her, and in its progress she remarked that she heard no noise of footsteps or any other of the usual sounds made in progression. She was now convinced that she was gazing upon a spectral illusion. The figure soon disappeared, but while it remained before her it appeared to conceal the objects before which it stood. Similar illusions were noted by Mrs. A. in the case of the cat, which she imagined she saw in the drawing-room, but which was at that particular moment in the housekeeper's apartment. Her husband was witness of the latter incident. Amongst the other figures which appeared to this lady was that of a female relative who was at the period in question in Scotland in perfect health, but whose image appeared enveloped in grave-clothes, and in the ghastly appearance of death. And on another occasion, when alone in her bedroom, and in the act of repeating a passage from the "Edinburgh Review" which had captivated her notice and memory, she beheld seated in an arm-chair a deceased sister-in-law. The figure was clad in a gown of a peculiar pattern which had been vividly described to her by a friend who had seen the deceased lady wear it. Here a dominant idea—that of the description of the dress—had probably lent its aid to increase the realism of, or even to produce, this particular phantom. In the case of another illusion, the figure of a second deceased friend sat down in a chair opposite Mrs. A., on an occasion when several other persons were in the room. Mrs. A. was afraid lest the fact of her staring persistently at what to her visitors would appear empty space should be noticed; and "under the influence of this fear," says Sir David Brewster, and recollecting that Sir Walter Scott in his "Demonology" had mentioned such a procedure, "she summoned up the requisite resolution to enable her to cross the space before the fireplace, and seat herself in the same chair with the figure. The apparition remained perfectly distinct till she sat down, as it were, in its lap, when it vanished."

The case of Mrs. A. presents some noteworthy resemblances to that of Nicolai. She was a person of imaginative disposition, and she was in feeble health at the period when the illusions appeared. Her strong common-sense, aided, as Sir David Brewster tells us, by a perusal of Dr. Hibbert's famous work on the "Philosophy of Appari-

tions"—wherein that learned author declares that "apparitions are nothing more than morbid symptoms which are indicative of intense excitement of the renovated feelings of the mind"—served to free Mrs. A. from ideas of supernatural visitation, by which, it is not too much to say, nine persons out of ten amongst ourselves would be apt to explain the unwonted appearances. The physiological explanation of cases of spectral illusions is, however, simple in the extreme when the possibilities of morbid and deranged sensation are seen to relate themselves in a very exact and plain fashion to the natural method of receiving impressions. Those parts of Mrs. A.'s brain, eye, and ear, and of Nicolai's brain and organs of sense, which, under normal conditions, would have been concerned in the reception of actual sights and sounds, were made active and operated under some internal cause to produce the unwonted phenomena. As we have already noted, it is highly probable that in so acting the sensory organs and brain are but reproducing from the background, and projecting into the foreground of consciousness, images of which the conscious memory retains no impression, but which have been received at some past epoch of the individual history, and which, under unwonted stimulation, are evolved so as to appear part and parcel of our own personality.

That this latter conclusion—namely, that of the act in question being essentially one of memory—is perfectly justifiable, is rendered strikingly apparent by the case of Mrs. A., all of whose apparitions were those of known persons, and thus were simple reproductions of mental images, in one of which—that of the deceased sister-in-law—a vivid description of a particular pattern of dress served to add to the apparent reality of the illusion. In Nicolai's case, the strangers who appeared to him were, in all probability, the images of persons whom he had either seen in bygone days, and of whom he failed to retain any recollection; or were those of people with whose figures or appearance he was familiar from reading. In our own experience, we can readily recall to mind instances of the sudden recollection of faces, figures, scenery, &c., the details of which may have long been forgotten, but which may be revived by the application of an appropriate mental stimulus. Such a thought serves to suggest the important part which what may be termed "unconscious memory" plays in the regulation of mind-affairs and in human existence at large.

This latter feature of the association with us as "ghosts" of the figures of persons with whom we have been formerly familiar—even when the fact of this familiarity has been forgotten—is very aptly illustrated by the incident which is headed "An Antiquary's Ghost Story." I quote the interesting recital, signed "Augustus Jessopp, D.D.," from the *Athenæum*, of date January 10, 1880:—

"Little more than two months have passed since my own personal

experience of mental phenomena was strikingly enlarged by the occurrence with which the following narrative deals. Yet already I find that round the original story there has gathered a surprising accumulation of the mythical element, and that I myself am in danger of becoming a hero of romance in more senses than one. As I object to be looked upon as a kind of medium to whom supernatural visitations are vouchsafed, and, on the other hand, do not wish to be set down as a crazy dreamer whose disorganised nervous system renders him abnormally liable to fantastic delusions, I have yielded to the earnest request of some who have begged me to make public the following paper. I am told that there are those who busy themselves in collecting similar stories, and, if it be so, it is better they should hear the facts from me than after they have passed through other channels. The narrative was written, at the request of a friend, not many days after the event, when all the circumstances were fresh in my recollection.

"On October 10, 1879, I drove over from Norwich to Mannington Hall to spend the night at Lord Orford's. Though I was in perfect health and high spirits, it is fair to state that, for some weeks previously, I had had a great deal to think about, some little anxiety, and some considerable mental strain of one kind or another. I was not, however, conscious of anything approaching weariness, irritability, or 'fag.' I arrived at 4 P.M., and was engaged in pleasant and animated conversation till it was time to dress for dinner. We dined at seven; our party numbered six persons. Of these four at least had been great travellers. I myself was rather a listener; the talk was general and discursive, and amused and interested me greatly. Not for a single moment did it turn upon the supernatural; it was chiefly concerned with questions of art and the experiences of men who had seen a great deal of the world, and could describe intelligently what they had seen and comment upon it suggestively. I have very rarely been at a more pleasant party. After dinner we played a rubber. We 'left off as we began,' and as two of the guests had some distance to drive we broke up at half-past ten.

"The main object of my going over to Mannington was to examine and take notes upon some very rare books in Lord Orford's library, which I had been anxiously wishing to get a sight of for some years, but had never been fortunate enough to meet with up to this time. I asked leave to sit up for some hours and make transcripts. His lordship at first wished me to let his valet remain in attendance to see all lights put out; but as this would have embarrassed me and compelled me to go to bed earlier than I wished, and as it seemed likely that I should be occupied till two or three in the morning, it was agreed that I should be left to my own devices and the servants should be allowed to retire. By eleven o'clock I was the only person

downstairs, and I was very soon busily at work and absorbed in my occupation.

"The room in which I was writing is a large one, with a huge fireplace and a grand old chimney; and it is needless to say that it is furnished with every comfort and luxury. The library opens into this room, and I had to pass out from where I was sitting into this library and get upon a chair to reach the volumes I wanted to examine. There were six small volumes in all. I took them down and placed them at my right hand in a little pile, and set to work—sometimes reading, sometimes writing. As I finished with a book I placed it in front of me. There were four silver candlesticks upon the table, the candles all burning, and, as I am a chilly person, I sat myself at one corner of the table with the fire at my left, and at intervals, as I had finished with a book, I rose, knocked the fire together, and stood up to warm my feet. I continued in this way at my task till nearly one o'clock. I had got on better than I expected, and I had only one more book to occupy me. I rose, wound up my watch, and opened a bottle of seltzer water, and I remember thinking to myself that I should get to bed by two after all. I set to work at the last little book. I had been engaged upon it about half an hour, and was just beginning to think that my work was drawing to a close, when, *as I was actually writing*, I saw a large white hand within a foot of my elbow. Turning my head, there sat a figure of a somewhat large man, with his back to the fire, bending slightly over the table, and apparently examining the pile of books that I had been at work upon. The man's face was turned away from me, but I saw his closely cut reddish-brown hair, his ear and shaved cheek, the eyebrow, the corner of the right eye, the side of the forehead, and the large high cheek-bone. He was dressed in what I can only describe as a kind of ecclesiastical habit of thick corded silk or some such material, close up to the throat, and a narrow rim or edging, of about an inch broad, of satin or velvet serving as a stand-up collar, and fitting close to the chin. The right hand, which had first attracted my attention, was clasping, without any great pressure, the left hand; both hands were in perfect repose, and the large blue veins of the right hand were conspicuous. I remember thinking that the hand was like the hand of Velasquez's magnificent 'Dead Knight' in the National Gallery. I looked at my visitor for some seconds, and was perfectly sure that he was not a reality. A thousand thoughts came crowding upon me, but not the least feeling of alarm, or even uneasiness; curiosity and a strong interest were uppermost. For an instant I felt eager to make a sketch of my friend, and I looked at a tray on my right for a pencil; then I thought, 'Upstairs I have a sketch-book—shall I fetch it?' There he sat, and I was fascinated; afraid, not of his staying, *but lest he should go.*

Stopping in my writing, I lifted my left hand from the paper, stretched it out to the pile of books, and moved the top one. I cannot explain why I did this—my arm passed in front of the figure, and it vanished. I was simply disappointed and nothing more. I went on with my writing as if nothing had happened, perhaps for another five minutes, and I had actually got to the last few words of what I had determined to extract when the figure appeared again, exactly in the same place and attitude as before. I saw the hands close to my own ; I turned my head again, to examine him more closely, and I was framing a sentence to address to him when I discovered that I did not dare to speak. *I was afraid of the sound of my own voice.* There he sat, and there sat I. I turned my head again to my work, and finished writing the two or three words I still had to write. The paper and my notes are at this moment before me, and exhibit not the slightest tremor or nervousness. I could point out the words I was writing when the phantom came and when he disappeared. Having finished my task, I shut the book and threw it on the table; it made a slight noise as it fell—the figure vanished.

"Throwing myself back in my chair, I sat for some seconds looking at the fire with a curious mixture of feeling, and I remember wondering whether my friend would come again, and if he did whether he would hide the fire from me. Then first there stole upon me a dread and a suspicion that I was beginning to lose my nerve. I remember yawning; then I rose, lit my bedroom candle, took my books into the inner library, mounted the chair as before, and replaced five of the volumes; the sixth I brought back and laid upon the table where I had been writing when the phantom did me the honour to appear to me. By this time I had lost all sense of uneasiness. I blew out the four candles and marched off to bed, where I slept the sleep of the just or the guilty—I know not which—but I slept very soundly.

"This is a simple and unvarnished narrative of facts. Explanation, theory, or inference," concludes Dr. Jessopp, "I leave to others."

Upon reading this interesting recital, and taking clue from Dr. Jessopp's closing words, a number of persons addressed letters to the editor of the *Athenæum* in explanation of the antiquary's experiences. Thus Dr. Wilks, F.R.S., of Guy's Hospital, wrote as follows:—

"Putting aside the supposition of a trick, the story resolves itself into the question whether the appearance of the man beside him [Dr. Jessopp] was objective or subjective. Under ordinary circumstances when we see an object the latter is material, and forms an image on the retina ; this is mentally known through a perceptive part of the brain ; the mere retinal image is not enough

to constitute vision, as pictures are constantly painted upon the retina which are never discerned. Now it is possible for this perceptive part of the brain to be thrown into an active condition quite independent of the normal stimulus conducted to it from the retina, and under these circumstances the person apparently sees an object which, by the law of our nature, is projected by him a certain distance before the eye. This is common enough in fevers and in *delirium tremens*, where patients see people and animals around them whose reality is such that the memory of these becomes a part of the experience of their future lives. In mental derangements these hallucinations are also common, and patients see objects and hear voices which have no external existence. So it is in our dreams, from which we may be suddenly aroused by a great noise where all is still around, the auditory perceptive centre of the brain having been abnormally excited.

"In normal conditions the sight of an object implies the painting of it on the retina, as the hearing a noise implies the vibration of the drum of the ear. If sight and hearing occur without these normal excitants of the nerves, the brain must have been stimulated from within, and the impressions are abnormal and subjective.

"At the present time we have no knowledge that anything in the likeness of a ghost or anything that has not a material basis can excite an image on the retina; whereas we do know that under abnormal conditions the brain may be stimulated so as to produce a visual impression independent of any such image on the retina. The probabilities are then immensely in favour of the appearance which the Doctor saw being subjective rather than objective. We have only to suppose that those very common abnormal conditions of brain which are observed in bad health may occur under exceptional circumstances in an otherwise healthy organ to account for the occasional appearance of ghosts.

"The probabilities are also in favour of this view from other considerations. First, there seems no reason why the spirits of another world should prefer midnight for their visits, but the reasons are obvious why we should conjure them up at that time. Then, again, the want of individuality shown by this particular ghost: an ordinary mortal would find it very difficult to put himself 'in exactly the same place and attitude as before' on his appearance a second time, as this apparition did, and then so dependent was it upon the observer, that when the latter put his arm up it was gone, and the same occurred on the second occasion on another movement. How these movements of the Doctor could have affected a real object does not seem clear, nor why it could not be gazed at from different points of view. It may be noticed, too, that its nearness corresponded with the focussing of the Doctor's eyes to objects close around him."

In my own turn I wrote to the *Athenæum* as follows :—

"As the narrator leaves explanation to others, will you permit me to remark that his experiences very aptly illustrate to my mind a simple and readily explicable case of 'subjective sensation'? As such, Dr. Jessopp's ghost is explicable satisfactorily to the physiological mind on the idea that an image has been retained and formed in his sight-centres, and has been unconsciously projected forwards from the background of consciousness to assume (to the subject of the illusion) the veritable appearance of a human figure or spectre. The well-known case of Nicolai, the Royal Academician and bookseller of Berlin, is the best known recorded instance of similar visitations; and Sir David Brewster, in his history of 'Natural Magic,' gives the case of a Mrs. A., who was a ghost-seer of somewhat remarkable kind. Cases such as those illustrated by Dr. Jessopp are by no means unknown in medical practice, and are explicable on the theory of reversion of the ordinary phenomena and routine of sensation.

"The only point concerning which any dubiety exists concerns the exact *origin* of the specific images which appear as the result of subjective sensory action. My own idea is that almost invariably the projected image is that of a person we have seen or read about. It is not necessary that we should remember the incident to reproduce it thus; for 'unconscious memory' is a notable fact of mental life. In Dr. Jessopp's case there is one fact which seems to weigh materially in favour of the idea that the 'spectre' which appeared to him in Lord Orford's library was an unconscious reproduction of some mental image or figure about which the Doctor may very likely have concerned himself in the way of antiquarian study. He describes the figure as dressed in the costume of a past age. Does not this fact alone testify to the appropriateness of an antiquary's 'illusion' being drawn by memory and imagination from the days of old and from the forms of the past? Mental physiology has not yet sufficiently progressed to enable us to satisfactorily and fully explain the *rationale* of the mental acts which evolve the spectral illusion, but I would fain add, in conclusion, that such facts of mind as are already within our ken place cases like that of Dr. Jessopp within the pale of a rational explanation; whilst our best thanks are due to the narrator for his record as an aid to the diffusion of a plain understanding of 'ghosts' on a scientific basis."

It formed a feature in the discussion of the highest interest to me personally, to find my suggestions corroborated in a succeeding number of the *Athenæum* by Mr. Walter Rye. This gentlemen said:—

"Dr. A. Wilson's solution, viz. 'that the "spectre" . . . was an unconscious reproduction of some mental image or figure about which Dr. Jessopp may very likely have concerned himself in the

way of antiquarian study,' seems the right one, and I think I can identify the 'ghost.'

"The ecclesiastically dressed large man with closely cut reddish-brown hair and shaved cheek appears to me the Doctor's remembrance of the portrait of Parsons, the Jesuit father, whom he calls in his 'One Generation of a Norfolk House' 'the manager and moving spirit' of the Jesuit mission in England, and who is described as 'tall and big of stature, smooth of countenance, beard thick and of a brown colour, and cut short' (p. 95). Dr. Jessopp, when he thought he saw the spectre, was, at dead of night, alone in an old library belonging to a Walpole, and Father Parsons was the leader of Henry Walpole, the hero of his just-cited book. Small wonder, therefore, if the association of ideas made him think of Parsons.

"Probably every one who has specially studied the history of any family has framed for himself a vivid fancy portrait of one of its members. Having been working for some years at the pedigree of Isham of Lamport, I conceived just such a one of young Sir Thomas Isham, who died in the year 1681, very shortly before the day fixed for his marriage; and one night, when in bed at Lamport Hall, the reproduction of my idea visited me, sat by my bedside, and conversed for some time with me very affably, giving me various details as to the cause of his death, &c., some of which I regret, for the sake of the spectre's veracity, to say I have since found to be wholly incorrect. I was certainly under the impression the next morning that I had only had a very vivid dream, just such another, in fact, as that which I shrewdly suspect Dr. Jessopp had whilst admittedly yawning over his books in Mannington Hall. The fact, common to both our experiences, that we were not at all afraid of our visitant seems to strongly bear this out, for if, when undoubtedly wide awake, we were to meet a conventional white-robed ghost in a dark lane, we should, I do not doubt, be abjectly afraid of it. But there is great virtue in the 'if.' The first disappearance of the 'spectre,' as it were with a jerk, at a movement of the seer's arm, and its equally jerky disappearance at the fall of a book, remind one much of incidents happening during those short, sweet snatches of sleep not unusually stolen during dull sermons, snatches which cannot last more than a second or two."

The case of Dr. Jessopp's ghost becomes of extreme interest, therefore, when treated as a subjective and unconscious reproduction of sensations or ideas with which he was familiar enough, but of which at the time his memory apparently entertained no recollection. We can readily imagine that had such an incident occurred in the experience of an uneducated and superstitious person, how stoutly would all attempts at rational explanation have been combated. It is really because the spiritualist, the theosophist, the ghost-seer, and

the votary of "second sight," will not realise the possible conditions of their own nervous acts, that such persons inflict upon the world the tales of their mystic experiences, swaddled in the bonds and trammels of the beliefs and mysteries which breed and grow only in religions to which the light of scientific experience is not allowed to penetrate.

A scientific theory of ghosts is thus not merely possible, but in the highest degree probable, as resting on a scientific basis. But there are other matters to which a study like the present intimately relates itself. The vitiation of testimony by the aberration of the senses—or even the variations between the evidence of one witness and another, become explicable on the basis of varying sensations thus laid down. Nor does the domain of religion escape physiological attention. The mystic experiences of votaries and the heroism of martyrs may alike be capable of explanation under the belief of that exaltation of sense, and of the alteration of sensations and feelings, which appear to affect every period of human history, and which indeed often embody many of the peculiarities of each individual epoch. No less intimately, however, does the present subject concern that idealisation of material things in which the highest genius of poet, painter, sculptor, and musician may be said to reside. The creations of the brain are not wholly on the side of phantasy; and from the subjective side of human nature, the distilled and purified feelings of mankind may be evolved in thoughts that live for aye. But the gradation betwixt the æsthetics of sensation and the abnormal play of impressions is still clearly marked and plainly apparent. There are few higher missions or triumphs than those of "star-eyed science," which, taking as its theme the creatures and coinages of the brain, may show us the stern realities and facts which beset and often underlie the veriest dreams and phantoms of our life.

ADDENDUM.—The views offered in the preceding pages regarding the real meaning of the "phantasms of the living," are not likely to meet with the approval of a certain section of philosophers, whose anxiety to explain the ghostly visitations on a supernatural basis stands apparently in inverse ratio to their knowledge of mental physiology. We hear of psychical societies and other bodies, instituted, as far as one can discover, not for the purpose of calmly and scientifically investigating cases of apparitions so-called, but in order to square the stories of ghosts with the views of believers in a ghost-world. It is very satisfactory to be able to meet delusions of this kind by a series of hard and fast facts. Dr. Henry Maudsley, in his recently published work entitled "Natural Causes and Supernatural Seemings," gives a very telling example, firstly, of the manner in which the apparition-

stories gain credence, and secondly, of the promptitude with which the windbag of fiction is pierced and annihilated by the lance of fact.

In the *Nineteenth Century* for July 1884 appeared an article written by the Secretaries of the "ghost-seeking society." In the course of this article the ghost-seeing case of Sir Edmund Hornby, late Chief Judge of the Supreme Consular Court of China and Japan, is duly related. Sir Edmund "describes himself," says Dr. Maudsley, "as a lawyer by education, family, and tradition, wanting in imagination, and no believer in miracles." Notwithstanding his unsusceptible nature, Sir Edmund Hornby was evidently a personage with whom the ghost-idea was a favoured institution. "It was his habit," says Dr. Maudsley, "to allow reporters to come to his house in the evening to get his written judgments for the next day's paper. On this occasion he had written out his judgment, and left it with the butler for the reporter, who was expected to call for it. Having gone to bed and to sleep, he was awakened soon by a tap at the door, which when he took no notice was repeated. In reply to his call 'Come in,' the reporter solemnly entered and asked for the judgment. Thereupon ensued a dialogue between Sir E. Hornby—who referred him again and again to the butler, protesting against the unwarrantable intrusion—and the reporter, who persisted in his earnest requests for the judgment. Impressed at last by his solemn earnestness, and fearful of awakening his wife (who had slept soundly during all the energetic and animated dialogue), Sir Edmund gave him the gist of the judgment, which he appeared to take down in shorthand, after which he apologised for his intrusion and withdrew. It was then just half past one. When Lady Hornby awoke, as she did immediately, the whole incident was related to her.

"Next day, when Sir Edmund entered the Court, the usher announced to him the sudden death of the reporter some time between one and half past one. The cause of death, as ascertained by a formal inquest, was heart-disease. The poor man had not left his house the night before.

"Here, then, is a precise and circumstantial story related by a person of eminence and ability, accustomed to weigh evidence, and confirmed (for the writers say so) by his wife. Naturally it attracted much attention, and much jubilant attention from those who were specially interested in ghosts and apparitions. The *Spectator* saw in it, I believe, incontestable proof of the reality of the spiritual world. Amongst others, it attracted the attention of Mr. Balfour, the editor of the *North China Herald*, who was well acquainted with Sir Edmund and the reporter alluded to. In a letter to the *Nineteenth Century* (November 1884) this gentleman asks the editor to compare the story with the following remarks :——

"'1. Sir Edmund says Lady Hornby was with him at the time, and

subsequently awoke. I reply that no such person was in existence. Sir Edmund's second wife had died two years previously, and he did not marry again till three months *after* the event he relates.

"'2. Sir Edmund mentions an inquest on the body. I reply, on the authority of the coroner, that no inquest was ever held.

"'3. Sir Edmund's story turns upon the judgment of a certain case which was to be delivered next day, January 28, 1875. There is no record of any such judgment in the *Supreme Court and Consular Gazette*, of which I am now Editor.

"'4. Sir Edmund says that the Editor (reporter?) died at one in the morning. This is wholly inaccurate; he died between eight and nine A.M., after a good night's rest.'

"The Editor of the *Nineteenth Century*," Dr. Maudsley continues, "having submitted Mr. Balfour's letter to Sir E. Hornby, subjoins that gentleman's rejoinder, in which, after accusing Mr. Balfour of want of good feeling and taste in not having written to him privately, instead of amusing the public at his expense, he practically, though ungraciously, admits the whole case against him.

"It is probable," concludes Dr. Maudsley, "that similar stories of the kind would collapse in a similar manner were they tested properly by independent observation and inquiry, and were some one willing to take the trouble to make the inquiry, and, having made it, to take the trouble of contradicting them and exposing them."

Comment on the above case is needless. The mental attitude also of those whose belief in ghosts and apparitions can be bolstered up into a state of profound sincerity by recitals of which the foregoing is an example, lies practically beyond the region and field of sober criticism.

XV.

THE INNER LIFE OF PLANTS.

THERE can exist no doubt that the popular idea of a plant in respect of its living powers is that of an organism which merely hovers, so to speak, on the verge of existence. The notions that plants may possess sympathies and feelings—or, to speak more physiologically, "sensations"—and that they are by no means the inert beings which everyday-philosophy supposes, have not yet dawned upon the popular intelligence. Yet the last decade of science has certainly tended to raise the plant as a living, and moreover as a sympathetic and active being, in the botanist's estimation. The Linnæan maxim that "stones grow," that "plants grow and live," and that "animals grow, and live, and feel," no longer expresses the gist of botanical ideas concerning plant-life and its varied interests. For one thing, we certainly know of many plants that not only "feel" as accurately and as sensitively as many animals, but exhibit a far higher range of sensation than animals of by no means the lowest grade. And, as the sequel may show, we are acquainted with many instances among plants of the selection and pursuit of a particular way of life, as intelligent indeed as the corresponding choice and pursuit of habit amongst many of their animal neighbours.

It is true that we can hardly criticise the popular idea of the inertness of plant-life too severely, when we consider that to the uninitiated eye the world of plants does not present any signs or symptoms of ordinary, not to say marked, activity. Although Wordsworth long ago declared his belief that the flower was not insensible to the enjoyment of the air it breathed, the idea thus mooted of the active personality of plants was far too vague and poetic to influence the popular mind in its estimate of the physiological ways of the vegetable kingdom. Furthermore, it might be asked, does not the evidence of the senses—constituting, as every one knows, the sole but inefficient criterion of what is and of what is not—convince us that the plant-world is simply a huge repository of unfeeling organisms, whose right and title to the idea of life is best expressed by the secondary meaning which has come to be attached to the word "vegetate"? Does the flower feel the massacre of its petals as it is slowly vivisected beneath the hand of its fair and unthinking possessor? Or does the tree heed the axe

or saw which despoils it of its branches, or which may fell it in all its glory to the ground? So apparently negative are the replies to these questions, that, in so far as the evidence of the senses is concerned, the opinion that plants merely grow and nothing more seems at first sight of most justifiable kind.

But the evidence of the senses does not terminate in scientific investigation where it ends for the popular mind. The knowledge that the best part of our universe is hidden from the "unassisted sight," and that the "music of the spheres" is altogether unheard by the ordinary ear, warns the botanist of possible and serious error in the common estimate of the plant. Locked up within the tissues of the living plant wherever found, and of whatever rank the plant may be, the microscope, for example, discloses the curious "protoplasm," through the substance of which never-ending currents and tides are seen to pass. The busy streams that course up and down the microscopic stinging hair of the nettle-leaf, and the tides that throng the tissues of the lordly oak or giant *Sequoia* itself, show clearly enough that, whatever plant-life may appear to the ordinary observer, the stillness of the forest is after all more apparent than real. Each plant is thus, at the very outset of the botanist's studies in the minute, discovered to be the seat of vital activities of highly complex order. It is through these protoplasmic currents that the life of the plant is maintained, and it is by means of these hidden activities that the various known aspects of plant-life are manifested. The production of the embryo-plant, its gradual formation into the likeness of the young organism, the production of the leaf and flower, the mysterious fertilisation of the ovule, and the appearance of fruit and seed as the final terms in the "ages" of the plant, are each and all wrought out by means of the activities of its protoplasm. Erasmus Darwin, writing in his day of the life of plants, says :—

> Thus, while the vegetable tribes inhale
> The limpid water from the parent vale,
> Their vegetating organs decompose
> The salutary compound as it flows;
> And by affinities unknown dispart
> The subtle hydrogen with chemic art,
> To blend it with the carbon of the air,
> And form the rose, the pink, the lily fair.

Had that eminent philosopher been acquainted with the physiology of plants as that topic is understood by us to-day, he would have been enabled to refer his "affinities unknown" to the powers of the living matter which, as we have seen, makes each plant, apparently inert and stable, the repository of ceaseless action. On the very threshold of botanical science, then, we discover that it is necessary to prepare ourselves for a sweeping change of ideas regarding the inner life of plants. It may, in fact, be laid down as a rule, desti-

tute of the proverbial exceptions, that every phase of recent research in botany has but served to show us that the world of plant-life is not merely a universe of activity, but that it has even its own analogies, in the way of likes and dislikes and of mental phenomena, to the phases we see in the animal world, and, indeed, in ourselves.

One of the most interesting of those aspects of plants, in which they may be regarded as approaching the animal world in their constitution, relates to the marked influence of what may legitimately be named *habit*. That the animal frame should present itself as the seat of definite actions which become perpetuated and repeated in the individual history, until they become part and parcel of the constitution of the race, is, of course, tacitly admitted to be a common and familiar feature of the animal constitution. It may in the same way be shown that in plants the influence of "habit" is as powerfully exhibited as in the neighbour-kingdom. For instance, in the earliest phases of plant-growth, the influence of habit as affecting that growth and development may be plainly observed. When the structure of an ordinary seed, such as that of a pea or bean, is investigated, it is found to consist of certain coverings, of two bodies called *cotyledons* or "seed-leaves," of a young root or *radicle*, and of a youthful stem, the *plumule* of the botanist. The two latter parts, in fact, form the young plant. Through their development, the plant will ultimately appear in all the fulness of growth and perfection. Now, when such a seed germinates, the radicle, or young root, is the first structure to break through the coverings of the seed, being followed in due course by the youthful stem. It constitutes a remarkable and at the same time interesting feature of plant-habit, to discover that whatever the position of the seed, the young root invariably seeks the ground, whilst the stem as invariably avoids the ground and seeks the light. If, for example, the root on emerging from the seed should point upwards, it will gradually curve as it grows, so as to enter the ground; whilst the young stem in such a case, placed at first in the position of the root, will, in its turn, adjust itself to the exigency of its position and curve itself so as to grow upwards. Associated with the tendency or habit on the part of the young root and stem of growing each in its proper direction, we discover certain peculiar structural conditions. That the growing parts of the plant are influenced by gravitation is, of course, unquestionable. It has been ascertained that if a growing stem and root are laid horizontally, the stem will bend so as to render its upper side concave and its under surface convex. Thus its extremity comes to grow upwards; but in the root the reverse action takes place, and the under side becoming concave whilst the upper surface is convex, causes the root-tip to seek the ground. The influence thus exerted by gravity on the growing parts of plants is termed "Geotropism;" and it may readily

be understood how rigidly plant-habits must mould the life of the vegetable world, with the stable force of gravitation serving as an all-important condition in the formation and continuance of these habits. We shall presently observe that the influence of light on the growing plant is to be regarded as a second factor of importance in the formation of the habits of the plant-universe.

But it might be urged that the fixation and rigidity of the habits in question should preclude the plant from participating in those modifying circumstances to which the worlds of life are now universally regarded as subject. If variation and change, as factors in producing new species, are to be regarded as operating influentially within the plant-domain, it must be shown that the instincts of the plant should be capable of being affected by alterations of its environment and surroundings. Such an expectation is amply fulfilled by the result of botanical research. We know that it is the habit of the plant-root to grow downwards in obedience to gravity, as, contrariwise, by the greater growth of the under side of the, at first, horizontal stem, its point is forced upwards and from the earth towards the light. But these natural habits may be interfered with and altered, as already remarked. If seeds be placed amongst damp sawdust in a perforated and suspended zinc frame, they at first obey the law of habit which compels them to grow downwards into the air, as if seeking their native earth. But the dry air presents less attraction for the young roots than the moist sawdust. Starvation awaits them below, whilst they have just grown through a land of plenty, as represented by the moist sawdust of the frame. Hence, an instinct which may appropriately enough be termed that of self-preservation influences the rootlets; and instead of continuing their profitless downward increase, they return to the moist sawdust above. The mere structural explanation of these movements, as connected with greater growth above or below on root and stem, does not in the least degree affect the question of the habit and instinct involved in plant-life. The habit is merely manifested through such growth; behind and above the structural modification and growth are the forces or conditions of which that growth is the result. Through similar habits, plants are enabled to overcome the difficulties and disadvantages of their lives, just as the animal may adapt itself to the exigencies of any unwonted condition. Thus, when the field of wheat or corn is laid by the storm, the habits of the plants may aid in recovering their lost position. Resting horizontally on the ground, the under side of the wheat-stalk grows more quickly than the upper side, and in this fashion, adjusting itself to its difficulty, the recumbent stalk is forced upwards to its erect posture.

More subtle, because the conditions are more difficult of investigation, are the relations between plants and light. That light plays

an all-important part in the economy of plants every school-boy knows. The bleached, or, as it is technically named, "etiolated," appearance of the potato-leaves which have grown in a damp and darkened cellar, is familiar to all. Instead of presenting their normally green appearance, the potato-leaves are yellow; and instances of the blanching of esculent plants by the gardener, through the influence of darkness, are too familiar to require mention. It is not too much to say that light is absolutely necessary under ordinary circumstances for the growth of plants. Only in the presence of light can the green-colouring matter, or "chlorophyll," of plants be developed; and, as this substance plays an important part in the nutrition of plants, the absence of light simply means starvation or death to all normally green plants. Curiously enough, however, light is known to retard plant-growth, even whilst it is essential for the performance of the chemical actions through which ordinary plant-life is maintained. Potato-stems grown in a dark cellar, for instance, are much longer than the ordinary stems grown in the light. When a plant is subjected to light from a window, the side of the stem farthest from the light grows longer than the opposite side, and as a result the plant curves towards the light. Such a feature is paralleled in the animal world by the habit of sea-anemones, which, when confined in a clear glass vessel, shift their position towards the light when they have been deprived of the light-rays by changing the situation of the vessel; and the little hydræ of the pools and ditches similarly congregate invariably on the side of their glass which is next the light. Most parts of plants, in their natural growth, possess this habit of curving towards the light; and such a habit has been appropriately named "positive heliotropism" by the scientific botanist. The well-known legend of the sunflower (*Helianthus*), that

> Mad Clytie, whose head is turned by the sun,

will naturally be brought to remembrance by the recital of the sober facts of physiological botany. Churchill's description of the sunflower as—

> The proud giant of the garden race,
> Who, madly rushing to the sun's embrace,
> O'ertops her fellows with aspiring aim,
> Demands his wedded love, and bears his name,

forms, after all, by no means an inapt commentary on this curious plant-habit, which is paralleled by the observation of the equally curious habit of the corn, the ripe ears of which incline to the south, and rarely, if ever, turn northwards. So also the curious "compass-plant" of America (*Silphium*) may be said to illustrate a similar or analogous habit. It is this plant which Longfellow speaks of as—

The compass flower, that the finger of God has suspended
Here on its fragile stalk to direct the traveller's journey
Over the sea-like, pathless, limitless waste of the desert.

The plant is alleged to set the edges of its leaves directly north and south, and Sir Joseph Hooker adds that, from his observations, he believes that the leaves present their faces parallel to the meridian line.

FIG. 30.—LEAVES OF SENSITIVE PLANT (expanded above and closed below).

The effect of varying light-rays on plant-life presents several interesting features for remark. The varied light-rays of which daylight is composed do not, as might be expected, possess the same effects on plant life and growth. Plant-habit, in a word, again shows itself very markedly in its varying susceptibility to different light-rays. Thus, a green plant largely subsists on the carbonic acid gas which it decomposes, in the presence of light, into its carbon and oxygen, retaining the former for food, and setting free the latter. Now, it has been experimentally proved that, in respect of the influence of the light-rays on this chemical process, the red and orange rays are most powerful ; next succeed the yellow rays ; the green rays come next in order ; whilst the blue and violet rays rank as the least powerful in the scale. But if the yellow rays are the most powerful in aiding the plant to obtain its carbon-food from the air, these rays are least effective in producing mechanical alterations in plant-structure. For it is the refrangible violet rays which in the formation of plant-habit have operated most powerfully in the production of plant-movements, whilst the red rays have no effect. When stems and branches are influenced by and drawn towards the light, the blue and violet light-rays are paramount. On sensitive plants, these rays also exert a stimulating action, but the red and orange rays cause such plants to assume the position and attitude customary to them in darkness.

When a plant, such as the Mimosa (Fig. 30), or sensitive plant, whose leaves droop when they are touched, is placed for some time in darkness, the movements disappear completely; and when such a plant is placed in the light, the power of movement is not restored for some hours, or it may be days. A sensitive plant, which is very liable to be affected by alternations of light and darkness, may be rendered motionless by being simply placed in a feeble light. In

FIG. 31.—OXALIS, OR WOOD SORREL, WITH CLOSED LEAVES

such a case, or when placed in the dark, the plant becomes rigid. In the Wood Sorrel, or *Oxalis* (Fig. 31), the leaves of which open and close under stimulation, light causes the leaves to expand. In the still more curious *Desmodium gyrans* (Fig. 32), or Moving Plant of India, whose small lateral leaflets exhibit continual movements, both vertically and in a circular direction, the motion continues even in the dark, provided a proper temperature be maintained. This plant,

often named the "Telegraph Plant," ceases its movements when the temperature is below 22° Cent. Desmodium appears, therefore, to have overcome that dependence on light to which other plants are subject, and exhibits a tendency to regard temperature as the ruling condition of its life.

There exists a striking analogy between the health and growth of man or other animal and that of a plant, in respect of the influence exerted upon either by light and darkness. As the child grows stunted, pale, and weak when bred in the close, dark city court or alley, and appears in striking contrast to the healthy, ruddy-complexioned country urchin, so the plant, grown in the darkness, contrasts unfavourably with the normal organism grown in the daylight. Habit and instinct in the ordinary plant have apparently moulded its normal constitution in accordance with the same laws which regulate the well-being of the animal. Experimentally treated, the topic of the influence of light on plant-growth is best illustrated by an experiment in which twelve seeds of Indian cress were placed in three pots—four seeds in each pot. The first pot was placed in complete darkness, with the result that the seeds germinated only to an extent compatible with the usage of the nourishing matter originally inherent in their substance. Like a man living on capital, and deriving no income from active work, these first seeds perished as soon as that capital came to an end. In the absence of light, the chemistry of the plants could not be exercised. Surrounded by soil and food, they were unable in the absence of light to avail themselves of the nutriment at hand. The second pot was, however, daily placed for seven hours in daylight. At the end of three months, the plants had gained in weight by five grammes. The third pot had continual exposure to light, with an afternoon share of sunlight, and, in the same space of time as that accorded to pot number two, the plants had gained twenty grammes of dry weight.

FIG. 32.—DESMODIUM, THE MOVING PLANT OF INDIA.

All parts of a plant, however, do not appear to require light as a vital necessity, and this declaration may be extended to include

those plants each of which as a whole does not contain green-colouring matter. A seed itself germinates in the dark; and the work of bulbs and tubers in producing their characteristic plants takes place, as every one knows, independently of light. Even the annual layers of new wood that increase the growth of a tree, are produced beneath the bark, and necessarily in darkness. Again, the habits of plants, like the habits of the highest life, may exhibit strange contradictions in the matter of the necessity or demand for light. Thus, the seed-leaves of many members of the pine order become green notwithstanding the darkness, and the same remark holds good of the fronds of ferns. But a far wider generalisation may still be made regarding the question of light and no light in the habits of plants. Any plant which in its natural state does not develop green colour is, of course, practically independent of light as a condition of successful vitality. A mushroom, toadstool, or other fungus, for example, does not require light for the performance of its vital functions. Many fungi grow in the dark. The familiar "truffles" are underground livers, and "moulds" certainly love the darkness rather than the light. These plants, curiously enough, and low as they are regarded in the botanical scale, exhibit a nearer relationship with the animal world than do their green and higher plant-neighbours. For instance, a non-green fungus inhales oxygen gas and exhales carbonic acid like an animal; whereas, as we have seen, its green neighbour absorbs the latter gas for food, and exhales oxygen under the combined influence of light and its green-colouring matter, and only at night, or in darkness, imitates the animal respiration. And, whilst the green plant lives on water, minerals, ammonia, and other lifeless material, the fungus, or non-green plant, demands "organic" matter—that is, matter which has been elaborated by a living being—for its support. As a matter of familiar observation, fungi and their neighbours possess the habit of locating themselves near decaying organic material, and in this respect prove themselves possessed of a "selective" power to which more particular reference will be made later on.

The hidden currents of plant-life have, however, developed certain remarkable instincts in the choice not merely of food, but also of habitat, which clearly prove that the plant-world is the seat of actions and habits that form a striking parallel to those of the animal world. It might, for instance, form an interesting inquiry to determine how and why certain fungi have come to select the human skin and that of lower animals as a habitation. A very large number of skin diseases are known to be the products of the growth and development, within the skin-tissues, of special forms of fungi. Even the silkworm and the fly appear to be infested by specific and "unbidden guests" in the form of lower plants, which firstly disease, and finally

exterminate, these insect races. The parasitic habit is one which is thus by no means confined to the animal kingdom, and it is further illustrated in certain plants of by no means the lowliest grade. The mistletoe, for instance, is a true parasite, since, sending its sucker-like roots into the substance of the oak or apple to which it has attached itself, it absorbs thereby the nutrient juices of its "host." By aid of its own green leaves, however, the mistletoe can elaborate a little food for itself, but its parasitic habits evidently supply it with the largest share of its nutritive material. Even more typical as a parasite is the *Cuscuta*, or dodder, which literally strangles flax, clover, the hop, and many other plants. The dodder begins its existence in a perfectly regular and normal fashion by germinating in the ground. But sooner or later the parasitic habit comes to the front. Above ground, the sucking roots are developed wherever the dodder comes in contact with its victim: and finally leaving the ground, this malignant growth fastens itself entirely upon the "host," and ultimately kills it by the strength and intricacy of its growth. There appears to be developed in the case of these parasites, as distinctive a series of habits as the animal world can show. In respect of the so-called "instincts" which the parasitic animal is believed to possess, it seems legitimate to claim for the plant at least an equal, if not more elaborate, development of a guiding and directing impulse towards a peculiar way of life. This latter contention becomes the more reasonable when we reflect that the assumption of the parasitic life has been attended in the case of the plant with a far more sweeping alteration of original habit and dietary than is usually the case with the animal which becomes a lodger or boarder on a neighbour form.

In respect of the *choice* of food, the inner life of plants discloses many curious examples of the "selective" habit already alluded to; whereby the plant appears to exhibit veritable "tastes," as capricious and apparently as undeterminable as those of higher life. The "bill of fare" of the ordinary plant naturally includes those elements which constitute, and which therefore go to make, the living protoplasm, on the presence of which the vitality of the animal and plant alike depends. Thus it may be said that all plants absorb carbon, hydrogen, oxygen, nitrogen, and sulphur, and to these essential elements must be added a further instalment of "chemical food," in which iron plays an important part. Now, in this statement of plant-dietary, there is nothing more remarkable than is included in the nutrition of the animal. But the animal is usually credited with its likes and dislikes, and is believed frequently to exhibit a preference for a special diet, or for one article of diet over another. Such a feature constitutes a perfectly normal phase of the highest existences, but it may prove somewhat remarkable if we

discover that certain plants have likewise developed tastes and predilections for special kinds of food. For example, it is interesting to find that some plants will not flourish unless zinc is included in the list of substances constituting their dietary. This metal is ordinarily unknown in the list of food-stuffs demanded by plants; yet *Viola calaminaria* and *Thlapsi calaminaris* present us with examples of plants for which zinc is a necessity in so far as healthy growth is concerned. Whilst a minute quantity of iron is necessary, as already noted, for plant-growth at large, certain plants appear to demand much larger quantities of this metal than are ordinarily supplied by the soil. Maize is an example of those plants, for the healthy growth of which iron appears to be an absolute necessity; and buckwheat will not grow unless the elements potassium and chlorine are supplied. The list of special proclivities in the way of choice of unusual food-ingredients by plants might be well-nigh indefinitely prolonged. Enough has been said, however, to show that there operate in the world of plant-life habits and conditions determining food-supply strikingly analogous to those which cause the animal to prefer one food-material, and to reject another. That this selective power in plants depends on what may be familiarly named "constitutional peculiarities" appears tolerably evident from the results of experiments upon the absorptive power of different plants when tested by the offer of a varied range of material. Certain plants (*e.g. Mercurialis annua*) have been known to exhibit a striking preference for nitre when that substance was mingled with common salt; whilst, on the other hand, a species of *Satureia* absorbed salt, but rejected the nitre. Arsenic, as a rule, is fatal to vegetable life; yet some fungi have been known to grow in solutions of this substance, exhibiting thus an adaptation to circumstances as typical as that afforded by any living form. This selective power, which forms such a marked feature in the inner life of plants, possesses naturally an economic and practical interest for the agriculturist. The "rotation of crops" practised by the farmer, is the result of a knowledge of the fact that one species of plants prefers what another species rejects; and it is the absence of the knowledge or the lack of attention to its teachings which has made the once fertile fields of Sicily and Spain utterly unproductive in the present epoch.

Far exceeding in interest the foregoing details respecting the development in plants of a predilection for special kinds of food, are facts (which the patient industry of Mr. Darwin was mainly incidental in bringing to light) respecting the extraordinary habits of certain species of higher plants which feed upon organic matter, and which appear to prefer such material when drawn and captured from the world of animal life. No more typical instances of the development of a special "habit" in plants could well be cited than the

case of these carnivorous plants. There can exist no doubt in the mind of the scientist that the habit in question has been developed; that, in short, it is acquired, and not original in its nature. Varied circumstances favour such an opinion, which is in perfect harmony, it need hardly be added, with the general doctrine of evolution, maintaining the production of new forms of life through the modification of the old. The carnivorous plants are thus discovered to unite singularities of structure to peculiarities in the way of diet. The modifications of habit which have made them animal-feeders have been accomplished *pari passu*, and through the development of structural changes in the leaf and in other features of their material organisation. The deviation from the usual and ordinary course of plant-life, here as elsewhere, betokens the beginnings of new and altered phases of existence. The variation from the old species, in a word, is but the prelude to the establishment of new species and of new ways of life.

One of the most powerfully convincing facts connected with the altered "habits" of the carnivorous plants and their allies, and demonstrative of the gradual modification through which their existent condition has been attained, consists in the observation that between their animal-like habits and the ordinary life of common and normal-living plants there are to be found many connecting links and stages. The assumption of a parasitic life by the mistletoe and other plants serves to show how an ordinary plant may acquire an abnormal or unusual habit without sacrifice of the essential characters of its plant-nature. It will be remembered that the mystic parasite of the oak and apple has green leaves of its own, and that it elaborates certain food-materials by aid of these organs. Although the mistletoe is by no means the first term in the series of links whereby the unusual is connected with the normal in plant-life, yet it serves physiologically as an interesting half-way house between its common neighbours and its carnivorous fellows. Mistletoe has developed the parasitic habit of dependence upon another living being, and that a plant, for the largest part of its dietary; but its relations do not extend outside the bounds of its own kingdom after all. Before, however, the mistletoe stage can be reached, certain preliminary conditions must have been represented and effaced in the development of the altered phases of life we now behold. Probably the first step in the development of a parasitic life in the higher plant began with mere attachment to a neighbour-plant. A weakly stem to-day climbs upon, or twines around, a support. The ivy, hop, French bean, honeysuckle and the like, illustrate not merely the stage of attachment by way of mere support—each plant having its own root in the ground—but we may also discover that in their ways and methods of climbing or twining, as the case may be, there are represented fixed and defined

habits which prove how closely the modification of their lives has affected their race and species. If we select the case of the ivy, for example, we note a weak-stemmed plant, developing on that stem clusters of small root-like processes, which, like the "hold-fasts" of the gardener, serve to attach it to the wall over which it may extend its growth, or to the tree on which it climbs. But the nourishment of the ivy, like that of ordinary plants, is a matter of ordinary root and leaf function. With leaves of its own, it can inhale and decompose its aerial food, and by means of its root it can absorb from the ground the food-materials which the soil supplies.

Let us now imagine the case of a plant in the ivy shape, with its false "roots" adhering to another plant, and which becomes accustomed to utilise these "roots" for nourishment. It is not difficult to conceive of such roots, at first used for fixation alone, becoming adapted for nutrition also. If we suppose that these "roots," penetrating the tissues of a tree, acquired a habit of absorbing nourishment in the shape of the tree's sap, we should thus outline the preliminary stage in the development of a more typical parasitic habit. As time progressed, that habit would assert itself with greater force. The absorption of ready-made sap on the part of any plant, is an easier and more satisfying process of nutrition than the work of elaborating sap on its own account. A clear advantage in the "struggle for existence" would thus be gained; and the effects of a rich and satisfying dietary would be sufficient to induce a further perpetuation and a yet higher development of the parasitic life. From the ivy stage, then, the plant might pass to the mistletoe stage, in which the connection between root and ground has been dissolved, and wherein the plant, whilst retaining its leaves, has become wholly dependent for fixation and lodgment on its neighbour-tree. How powerfully the case of the mistletoe has struck Mr. Darwin as dependent upon a multiplicity of causes, which originate and reside within the inner currents and constitutions of plant-life, may be gathered from his own words. "In the case of the mistletoe," says Mr. Darwin, "which draws its nourishment from certain trees, which has seeds that must be transported by certain birds, and which has flowers with separate sexes absolutely requiring the agency of certain insects to bring pollen from one flower to another, it is equally preposterous to account for the structure of this parasite, with its relations to several distinct organic beings, by the effects of external conditions, or of habit, or of the volition of the plant itself."

The case of the carnivorous plants and of their allies, which have just been mentioned as illustrative of the peculiar conditions that rule the inner life of plants, may be shown to exhibit an analogous course of development to that which has given us the mistletoe and its neighbours. Developing in another direction, it is true, and

eschewing the parasitic habit, the insect-eating plants have, nevertheless, certainly attained their present phases of existence through graduated stages, and through modifications of habit, of which clues and traces yet remain in the variations they exhibit before our eyes to-day. Thus there are several plants which probably represent the beginnings of the habit of feeding on other beings—animals or plants—and which live upon the matter arising from the decay of other plants. A peculiar orchid, the *Neottia*, or "bird's-nest" orchid, illustrates this peculiarity, the origin of which is traceable on the face of the habit itself. Mere growth amidst vegetable decay would suffice to account for its beginnings; and the absorption of such decaying matter might readily be conceived to become fixed as a habit of the species from the mere prevalence of the surroundings in question, and from the adaptability of the plant to avail itself of such food.

A step in advance brings us to the case of higher plants which feed on animal matter in a state of decay—a habit widely prevalent, as already noted, amongst the fungi at large. No better example of this condition can be found than the *Utricularias*, or bladderworts, which, as a rule, inhabit foul ditches, amidst the decay and putrefaction of which these plants flourish and grow. Here the acquirement of such a habit is again easy of determination. It is no unusual occurrence for insects and other varieties of animal life to come to grief in the neighbourhood of water, nor is it an unlikely circumstance that aquatic plants should present a convenient mortuary for such victims. The bladderworts of to-day, it is true, capture their insects or waterfleas, and even small fishes, on which they subsist, by means of the "bladders" borne on the plants, and from which they derive their familiar name. A peculiar valve closes the entrance to the bladder and opens inwards. Hence, on the principle of the eel-trap, or rat-trap, entrance to the bladder is easy, but escape impossible. The victims which enter the fatal cavern are confined therein; but it is only when death has ensued, and when their bodies have undergone the putrefactive process, that the absorptive powers of the plant come into play. It is necessary to insist on the recognition of this latter fact—namely, that the bladderwort lives upon the fruits of decay, and not upon fresh meat, so to speak; because this feature reveals the development and existence of a special habit in these plants, and one which goes to support the idea that the ways of plant-life are as remarkable for the adoption of favourable conditions as is the animal constitution. Mr. Darwin, speaking of his expectation that the bladders of *Utricularia* digested their prey, remarks that "to test their power of digestion, minute fragments of roast meat, three small cubes of albumen, and three of cartilage, were pushed through the orifice into the bladders of vigorous plants. They were left from one day to three days and a half within, and the bladders were then

cut open; but none of the above substances exhibited the least signs of digestion or dissolution, the angles of the cubes being as sharp as ever." As the result of this experiment, Mr. Darwin adds, "We may therefore conclude that *Utricularia* cannot digest the animals which it habitually captures." It was further noted that in most of the bladders examined, the imprisoned victims existed in the form of a pulpy, decayed mass, although whether the process of decay is simply a natural one, or whether, as some botanists suspect, it is hastened by the influence of a special secretion from the bladder itself, appears as yet to be undetermined.

Beyond the stage of the bladderworts, however, the inner life of the plant-world discloses a still more wonderful modification of plant-habit. There exists a goodly collection of plants which not merely capture living insect-prey, and that in a manner far more elaborate than is witnessed in the bladderworts, but which also literally digest and absorb their insect-food as perfectly as does the spider or other of its animal and insect-eating neighbours. The list of true carnivorous plants is long and varied. It includes the Venus' fly-trap or *Dionæa* (Figs. 35 and 36); the sundews (*Drosera*); the butterworts (*Pinguicula*), and other species of plants; and it further contains within its limits the most varied contrivances for effecting the capture of the prey. Perhaps the most convenient starting-point for the brief examination of the effects of plant-habit on the life of the organisms may be found in the case of the butterwort itself. Here we discover a plant, found as a rule in mountainous and marshy districts, and possessing short-stalked leaves of oblong shape. The edges of the leaves are curved inwards, and on their upper surfaces they bear numerous hairs, which are named "glandular hairs," for the reason that "glands," or bodies, adapted to secrete a fluid are associated with and included within their structure. These hairs, it should be noted, are mere modifications of the hairs so familiar on the leaves of most plants. The edges of the leaves are destitute of these hairs. Upon these leaves captured insects are commonly discovered; but, as Mr. Darwin aptly remarks, the mere fact of a leaf being capable in one fashion or another of arresting insects, is itself no proof of the carnivorous nature of a plant. At the same time, on the principle that it is *le premier pas qui coûte* in the modification of plant-life as in the course of human affairs themselves, it may be well to note that the beginning of the insect-eating habit may have lain in the mere accidental capture of the prey. We shall note that the simplest insect-eating plants lead us towards the more complex forms; and it is probable that in their turn such simple insect-eaters as *Pinguicula* represent mere developments of extremely common conditions in plants. Thus in a plant (*Mirabilis*) sticky hairs occur both on the leaves and stem. Furthermore, this plant continually captures insects by means of these

viscid hairs, but it exerts not the slightest power of digestion or absorption of the rich food thus captured—in a word, it can make no use whatever of the insect-prey, any more than the horse-chestnut can utilise the flies which adhere to the gummy surface of the scales which protect its leaf-buds.

But there are other plants, not ranked amongst the insect-eaters, and which nevertheless appear to possess potential qualifications for such a life. There are some species of the familiar Saxifrages, for instance, the glands of whose leaves possess powers of absorbing certain matters brought into contact with them; and a species of *Primula* has been experimentally proved by Mr. Darwin to be capable of exercising a like action. So that, as Mr. Darwin remarks, it is "probable that the glands of some of the above-named plants obtain animal matter from the insects which are occasionally entangled by the viscid secretion." Thus we are presented with a tolerably close series of links leading us from ordinary plants towards their insect-eating neighbours. Beginning with the plant which, like *Mirabilis*, preserves merely the power of capturing insects, but which makes no use of the food thus laid at its door, we pass to the saxifrage-stage, in which the insect-material adhering to the leaves is probably absorbed by the glands thereof, and this without any special modification of the plant-structure. Thence we arrive at the butterwort itself, a true insect-eater, but one of simple type, and such as may be held to represent merely a slight advance upon the saxifrage form. Progressive modification, then, cannot be doubted to have occurred in the development of these curious habits of plant-life; and although the exact lines and pathways of the modification are still hidden or obscure, the possibilities seen in the life and structure of the common plants around us testify plainly enough to the evolution of new structure and habit through the variation of familiar types.

The butterwort's method of insect-capture is in itself simple, and readily understood. When any object is placed near the incurved edge of the leaf, the leaf margin curls inwards, and then after a varying interval expands. This movement may be excited by various causes. Thus, pieces of glass, insects, drops of beef-infusion, and of carbonate of ammonia solution, produced the incurvation of the leaves; but drops of water, as well as drops of sugar or gum solution, had no such effect. The leaf will not incurve upon pieces of glass to the same extent as upon nutritive matters; nor does scratching the leaf produce any movement; such an observation appearing to indicate the existence of some amount of co-ordinated habit. But an important observation regarding this plant is found in the fact, that the period during which the leaf is incurved is remarkably short, as compared with that during which the leaves of other carnivorous plants remain closed. Thus twenty-four hours may

be taken as the average period of closure; but Mr. Darwin points out that very small objects, which may presumably be quickly absorbed, can thus be utilised in a short space of time, whilst insects are liable to be frequently washed under the incurved edges by rain, and are thus utilised more frequently for food on account of the comparatively short period of closure. Again, in the butterwort, if a large object excites the movement of the edge of the leaf, that object is pushed by the movement towards the middle of the leaf. It is thus brought in contact "with a far larger number of glands, inducing much more secretion and absorption than would otherwise have been the case." Lastly, it has been noted that fragments of plant-tissues and pollen-grains are also found on the leaves of the butterwort, and that, cannibal-like, the *Pinguicula* may therefore devour parts of its neighbour-plants. Relatively simple as are the expedients of the butterwort, it nevertheless appears to exemplify thoroughly the animal-habit of feeding on organic matter. Its roots are proportionately small, and it must therefore benefit largely from the nourishing dietary captured by its leaves, and absorbed by the glands borne on their surface. As a further proof of the development of special habits in the race, we may bear in mind that the glands of the plant are not set in action by mere contact with matters affording no soluble nourishment; whilst, when substances containing nourishing principles are applied to the leaf, the process of secretion from its glands is at once and profusely excited. Such an action, discriminating, so to speak, even in a blind fashion betwixt what is nutritive and what is innutritious, bears its own testimony to the singular likeness between the acts of animal-life and those of the specialised plant.

FIG. 33.—LEAVES OF THE SARRACENIA, OR SIDE-SADDLE PLANT, ONE OF THE PITCHER PLANTS.

A word or two regarding the well-known Pitcher plants and Side-

saddle plants is permissible here. The latter, *Sarracenias* (Fig. 33), are well known in the New World as fly-catchers. An attractive surface on the leaf leads the fly to its fate; a lower and glassy surface prevents its exit, once it has entered the leaf; and still lower down, is a surface studded with recurved hairs, which detains the captured animals. The pitcher-like leaves of the "side-saddle" plants contain fluid, but it seems pretty certain that the liquid in question does not exercise any digestive functions. A sugary secretion attracts the insect at the upper part of the pitcher, whilst below the true fluid of the leaf is found, and this latter possesses undoubtedly an intoxicating effect on insects. Experiment, indeed, has shown that this fluid intoxicates and finally kills insects; hence it is highly probable that the "side-saddles" feed on the putrescent and decayed organic matter, into which the bodies of the captured insects are finally resolved. The Nepenthes, or

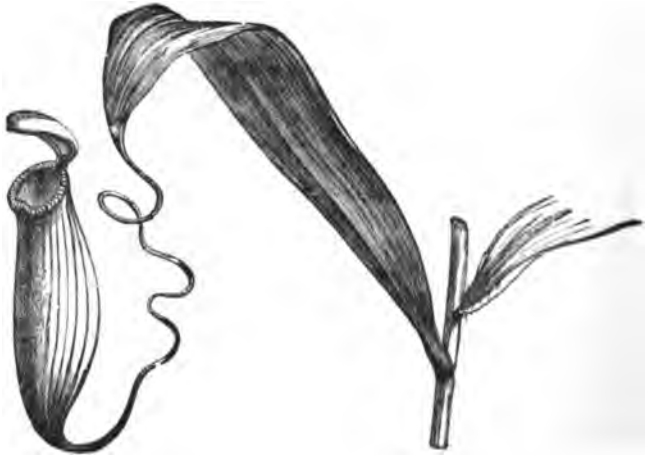

FIG. 34.—LEAF OF NEPENTHES, OR PITCHER PLANT.

true "pitcher plants" (Fig. 34), inhabit the Old World. In these latter plants it would seem that true digestion of the insect-food occurs. The "pitchers" are certainly contrived and adapted for the capture of insects, whilst the glands with which they are provided secrete a digestive fluid, by means of which the prey is dissolved and finally absorbed as food. The pitcher-plant's leaf is thus a veritable "stomach," and we must therefore rank these plants with the Venus' fly-trap and the sundew, as truly carnivorous in habit, and as evincing a high and specialised development of that habit, through which they become related to the animal world at large.

The *Drosera*, or sundew of our own bogs, and the *Dionæa*, or Venus' fly-trap (Figs. 35 and 36) of the North American marshes, introduce us to plants wherein the highest stage of carnivorous habit has been attained, and wherein special powers of sensibility and of reflex action have been developed to fulfil the purposes which produced and developed them. We are less concerned with the structure of these plants than with the effects on their habits which that structure is the means of producing. But it will be permissible very shortly to enumerate the modifications which distinguish each species. In both the seat of the modifications is the leaf. That of the sundew is shaped like a battledore, and bears on its surface numerous clubbed hairs or "tentacles," numbering from 150 to 250 on a single leaf. At the tip of each hair is the "gland," and the glistening secretion of these glands has given to the plant its popular name. When such an object as an insect touches the tentacles, these latter close over it, so as to pin it down upon the leaf surface, this process being really a preliminary to the death and digestion of the animal. Moreover, as if strictly imitative of the action of the animal in digestion, the tentacles of the sundew pour forth upon the insect a secretion which not merely, like the gastric juice of the animal, is antiseptic and preservative, but has digestive and solvent properties. In due time, therefore, the nutritive matters contained in the body of the prey are absorbed by the glands, and the organic matter of the animal is duly intussuscepted by the plant, which thus literally reverses the ordinary rule that the plant feeds the animal. That the life of the sundew has become permanently dependent upon this carnivorous habit, is clear from the fact that when insects are excluded from these plants they do not flower so perfectly, nor do they produce the number of seeds found in natural, that is, insect-fed specimens. In the Venus' fly-trap, the broad leaf blade (Figs. 35 and 36) is divided into two halves,

FIG. 35.—LEAF OF VENUS' FLY-TRAP (Open).

which close after the fashion of a rat-trap, and whose toothed edges fit one into another. The sensitive surfaces consist of three hairs (Fig. 36, *a*, *b*) on each half of the leaf, and upon these being irritated in any way, the leaf closes, and, in the case of an insect, imprisons it. When

the prey has been captured, the leaf-glands perform their digestive and absorptive function ; its body is disintegrated, and its nutritive parts absorbed ; such an operation requiring varying periods of time, extending from fifteen days to thirty-five days or more.

It remains now to show that the habits of these plants include certain remarkable features which certainly resemble those phases of

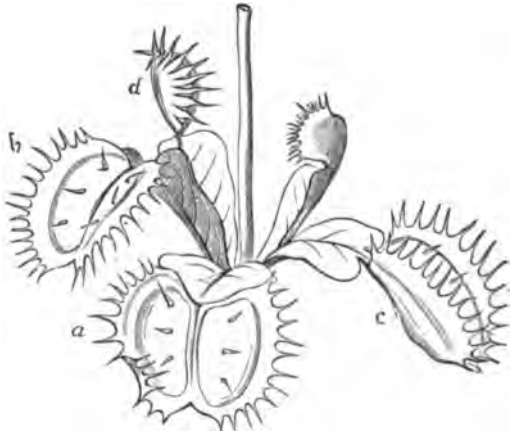

FIG. 36.—VENUS' FLY-TRAP.
(Leaf open at *a* ; partially closed at *b* ; and almost closed at *c*.)

the animal character that are commonly included under the term intelligent choice and selection. The observation of the sundew's life demonstrates that its tentacles will move and contract much more quickly when a piece of animal-matter is placed on the leaf than when any inorganic or mineral substance is offered to the plant. Nor is this all, for, as Mr. Darwin has shown, the tentacles of this plant will remain bent for an infinitely longer period over matters from which nutriment of any kind is to be extracted, than over particles which can afford no nourishment. So also the return of the tentacles to what may be named their state of rest is quicker when an inorganic particle has been the exciting cause, than when they have been stimulated by the presence of something eatable. This observation seems strikingly analogous to that whereby the animal form, after disappointment in the capture of prey, returns quickly to its lair. Such results, verified repeatedly, appear to suggest that in these plants there exists a discriminative power of by no means a lowly type, and which loses none of its curious nature by the reflection that it is exercised through the living protoplasm of the plant.

The sensitiveness of the sundew's tentacles is also worthy of remark. If a tentacle is touched once or twice only, it will not bend; yet even the slightest pressure, if prolonged, will cause its inflection. This feature has the valuable result of rendering the sundew insensible to the effect of raindrops; whilst the observation that even light and continued pressure affects the leaf, shows an adaptation admirably adapted for the capture of the lightest insect.

The result of experimentation upon the Venus' fly-trap presents us with equally instructive glimpses of the inner life of plants. Here we meet with a plant, the leaf-hairs of which are endowed with exquisite sensibility, even to the slightest and most momentary touch. Darwin tells us, for example, that a human hair, fixed into a handle, so that only an inch of its length projected, and used to touch the tip of a fly-trap's tentacle, produced instantaneous closure of the leaf. But it is equally interesting to discover that the hairs of the fly-trap are by no means so sensitive to "prolonged pressure" as are the tentacles of the sundew. The reasons for this difference in sensibility are not difficult to discover. The sundew depends for the capture of its prey, as we have seen, upon its ability to glue the insect firmly to the surface of the leaf. Continuous pressure, however slight, is therefore the best indication of the probability of a successful capture. But the fly-trap, depending upon sudden closure of its whole leaf for the replenishment of its commissariat, necessarily possesses an advantage over the sundew, but at the same time demands a sensitiveness equal to the task of acting at once and energetically upon the most momentary contact. Furthermore, as if demonstrating a still closer adaptation to the environments of its life, the fly-trap refuses to close its leaf on the mere stimulation of drops of fluid allowed to impinge on the sensitive hairs from a height. The raindrops in this case can therefore possess no effect on the plant; it is saved much useless contraction; and the observation likewise teaches us emphatically the highly specialised nature of the sensitiveness of this plant. The analogy between its sensibility to one set of impressions, and its indifference to others, reminds one forcibly enough of the specialisation of the sense-organs in the animal form. As the ear is excited only by sound-waves, or the eye by waves of light alone, so the fly-trap and sundew in their turn appear to possess special sensitiveness to those stimuli which are calculated to benefit their species.

Enough has now been said, perhaps, to show that within the plant economy there are included acts and habits strikingly analogous to many of those phases which we are too much accustomed to regard as the exclusive property of the animal. Our conceptions of the plant, in truth, require to be considerably widened in the light of recent research; and certainly the ruling idea of the

inertness of the vegetable kingdom, as compared with the animal world, can no longer on any ground be reasonably maintained. The origin of these peculiar phases of plant-life remains obscure; but the biologist legitimately enough may be led towards considerations connected with community of development, in his attempts to explain the likenesses which exist between the two great series of living beings. Despite the divergent lines along which the ordinary course of vegetable-life proceeds, when compared with the ways of animal existence, the analogies of the two kingdoms are writ large enough in the by-ways of plant-evolution.

XVI.

AN INVITATION TO DINNER.

An invitation to dinner from Mr. and Mrs. Smith has just been handed in by the postman, and the sight of the missive recalls visions of pleasant company and an enjoyable *menu*. Smith is, in the best sense of the term, a *bon vivant*. He takes care that "the feast of reason and the flow of soul" are respectively represented by the science and work of a *chef* who understands his business, and by the presence at his table of sensible people who can talk of something more elevating in tone than the pictures at the Grosvenor Gallery, and less bewildering than the "correlation of forces" or the "influence of heredity on developing organisms."

When I last dined at Smith's, even that eminent scientist Professor Caudal (whose theories respecting the disappearance of the tail in man and his poor relations are well known and appreciated at Burlington House) forgot his scientific joys and his mundane sorrows in the practical investigation of a lovely *pain de volaille aux truffes* which Smith's *chef* had elaborated to perfection. It is currently reported that it was the Professor whose appreciation of Smith's *filets de maquereau grillés* being disturbed by the clatter of a fair damsel whom he had escorted to table, gave rise to the well-known witticism of the comic papers. The lady in question had commenced an argument on evolution with the soup (which was *bonne femme*, and an especial joy of Caudal's), and had contrived a criticism of Spencer by the time the Professor's beloved *filets* appeared on the scene. Darwin and Huxley with the soup might be borne; but Spencer with the *filets* was too much for the Professor's prandial tastes. "Madam," said he, "your knowledge of facts is commendable"—this was Caudal's playful but porpoise-like fashion of allowing the young lady to fall partly from her position of scientific critic; "but," continued the Professor, "there is one fact of which you have failed to take due cognisance." "Ah, Professor," replied the lady, "I shall be so delighted if you will supply me with any facts which will aid my comprehension of evolution." Caudal's sonorous reply came during one of those mysterious lulls in the conversation which, as often as not, give the *coup de grâce* to some unfortunate and his opinions. "Madam," said the Professor, "you seem to have overlooked one fact of great importance." "Dear me!" replied the lady, "what is that?" "The fact, madam, that

our host has the best French cook in London!" I hear that the Professor's name is never mentioned now by the fair evolutionist. And I also learn that Caudal, with a wondrous chuckle, in which possibly a megatherium might have indulged in the days of its youth, is accustomed to relate the effectual method whereby he was able at once to silence a talkative neighbour and to ingest his dinner in peace.

Smith's dinner invitation, and the remembrance of the Caudal episode, have together set one's thoughts flying off at a tangent. Possibly it is the recollection of the professorial frame (which is large and bulky), in relation to the enjoyment of the process of nutrition at Smith's, which has caused me to think of dinners and dining in the abstract rather than in the concrete view of things. Be that as it may, I begin seriously to propound to myself the question, "Why do we eat our dinner?" and I find the reply to the question rather more difficult of solution than at first sight might be supposed. For one thing, it cannot be denied that, if the constitution of things human had been somewhat differently ordered, the race might have been spared a considerable deal of trouble, not merely in the work of dining, but primarily in the getting of dinners. To persons like Smith and Caudal, the latter task is of course a comparatively trivial matter. For them, the chief labour is the variation of their *menus*, and the satisfactory digestive disposal of the nutriment they imbibe. But what is an easy matter to many of us, namely, the finding of food, is a tremendous task to millions of our fellows. We are not yet beyond the possibilities of starvation; and the Oliver Twist maxim of asking "for more" is an actuality that animates very forcibly indeed the nutritive actions of tens of thousands of our race. There is no touch of cynicism in the idea that were the work of food-getting superseded by some easier process of sustenance, mankind at large would be saved a vast amount of trouble, and a very considerable portion of misery besides. But human bodies cannot grow like snowballs or stalactites. We cannot add new matter to our outside surfaces, and thus end the process and work of nourishment. Life everywhere is subject to the same rule which regulates humanity's unceasing work of food-getting; and Smith's dinner-invitation is only an additional and precise piece of evidence that, after all, Smith and his guests share the peculiarities of the animalcules and the special features of the plants. In other words, my dinner party is only a physiological necessity elaborated into a social display. Smith knows I must have my dinner, like the rest of the animate creation, including himself; and he is kind enough to ask me to give him my company in the performance of a work which he appropriately enough styles "the great event of the day."

The question, "Why do we eat our dinner?" is one worth

propounding, if only from the consideration that a little physiological discussion is necessary before we can completely or satisfactorily find its reply. Smith's dinner will be doubly enjoyable if I can satisfy myself why "dinner," or, to put it more generally, "food," is a necessity of existence. Amongst the obvious uses of science, I can conceive no more practical purpose than that which physiology can subserve, in showing me not only that dinner is a sheer necessity, but that the full enjoyment of that meal is a piece of highest wisdom. One wants an answer to the ascetics who regard the enjoyment of a good dinner as a "Philistine" proceeding, and who profess to maintain, on reasonable grounds, that dining out and dining well are equally barbaric and unnecessary customs. Let us see whether or not we may find in the pages of physiology, and in the daily experience of living and being, a full justification for both of these practices. If I may justify the necessity for eating dinner, and for enjoyment of the meal, as parts of the great order of natural law, Smith's invitation and its inspiration will together not have animated me in vain.

A glance at the flower-stand in the window supplies me with a fair starting-point for the argument and voyage of discovery. An hour ago my housemaid watered the flowers, plucked away the dead leaves, and set the vegetable kingdom in order for the day. My plants grow and thrive lustily. A few weeks ago that young fern plant, whose frond you see drooping gracefully over the edge of the pot, appeared above the earth as a curious little rolled-up bud, which, as it grew, appeared to mimic the head of the bishop's staff in shape. I could go back in the history of that fern frond if you wished, and could even show you that it sprang from a microscopic living "spore," which dropped one day last autumn from the back of a parent-frond. That spore grew into a green leaf, and from the under surface of this leaf the young fern was in turn produced. Now it has grown into a broad green frond, and there are others appearing beside it, which will grow to form, in time, a mass of fern foliage. Evidently, growth and enlargement are marked features of plant life, as they are plain facts of animal existence. As clearly one can see that growth in plants cannot take place without the presence and supply of matter to grow upon. So that, at the outset of our inquiry, we seem to arrive at the plain conclusion that plants demand food, for growth, equally with ourselves.

Suppose, however, Smith could have invited my fern to dinner instead of the fern's owner, the host would have discovered that the tastes, desires, and necessities of fern-existence were somewhat simpler, but not a whit less wonderful than his own. My plant would not have been at home at Smith's hospitable board. It would have

been much more uncomfortable there than, say, a railway navvy, whom Smith, in a moment of mistaken philanthropy, might have invited to form one of his dinner party. The navvy would at least have swallowed, by faith, the delicacies which Smith had provided, and might have made sad havoc with every course that was set before him. But my fern would have been unable to find anything on Smith's dinner-table which it could ingest at all; and, unlike the navvy, it would have proved itself a total abstainer, and have contented itself with *aqua pura* throughout the evening. In a word, the fern demands food of an utterly different order from that on which Smith and his friends subsist. Its wants are modest, like those of the immortal Mrs. Gamp; but, unobtrusive as they are, they must, like Mrs. Gamp's demands, be supplied, if plant life is to jog along on its accustomed course.

The fern, as type of the plant world at large, demands simply lifeless or inorganic matter for its support. For instance, it requires water, and my housemaid daily anticipates its wants in this respect. Its *menu*, if Smith had invited it to dinner, and if he had consulted Caudal (who is believed to know all about the proclivities of animals and plants, and especially the wants of the human animal in the way of food), would have been limited to four courses. Firstly, the fern would have taken water as its *potage*. All plants require a constant supply of water, which circulates through their tissues, and provides them with the means for dissolving and elaborating the solid parts of their food. These solid parts, it may be added, are always taken in solution—that is, are dissolved in the watery parts or constituents of the plant food. A plant has no mouth, hence its food must consist of liquids and gases. In this respect, it is the opposite of that eminent scientist Caudal, whose bodily presence is indicative of a reliance upon food constituents of solid kind; a peculiarity, it should be remembered, which of course is shared by our race at large. It is true that certain poor relations of the fern, like the corresponding connections of humanity itself, are given to grope and grovel for food in anything but æsthetic pastures; and it is also true that these same poor plant relations may, like animals, absorb solid nutriment. For example, what are we to think of a host of lower plants which have not a particle of green about them, and which, like *Æthalium*, or the "flowers of tan," growing in tan-pits, not merely absorb solid food, but creep about their habitations as if they mimicked the lower forms of animals? In truth, such plants do resemble the lowest animals in many aspects of their existence; but my fern might retort that as mere masses of living jelly, these lower neighbours of tan-pit society are not to be regarded as typical developments of plant life—any more, indeed, than a street Arab or a gutter child can be held to represent the genteel part of human existence.

So the fern's first course would be water. But dissolved in this *potage* it would obtain a second article of diet, namely, the *mineral* constituents of its food. Lime, potash, sodium, flint, and even zinc are found in the plant bill of fare which the botanist compiles. One member of the violet family has so far developed its special tastes in the way of food and feeding, that it will only flourish where zinc is contained in the soil. This *Viola* reminds one of Professor Caudal, and other eminent diners-out, who never enjoy their entertainment, unless their special brand of champagne, *brut*, is to the fore. Again, there are certain plants which, having no green colour, live on dead and decaying animal or plant matters. Such are the *fungi*, of which tribe the mushrooms are good examples. Then we also find plants of higher rank than the fern, which capture insects for their food. A "Venus's fly-trap" closes its leaves on the flies that alight upon them, and eats and digests the fresh insects. A pitcher-plant drowns insects in its hollow leaves, and, allowing them to putrefy, absorbs and grows upon their decaying bodies. It is remarkable, to say the least, that in plants we should find habits to vary in so marked a fashion; and it is also peculiar to discover that whilst, like some human beings, certain plants eat their food fresh, other plants, like many people we know, seem to prefer their food or game in a "high" condition. The taste for "high" dainties, so far from being an exclusive trait of culture in man, is an actual feature of many higher and lower plants. Even Professor Caudal, in his taste for grouse *passé*, finds his nearest analogy in the pitcher-plant and the mushroom.

But we are wandering from the diet of the fern. Its first course was the water, and its second the minerals that fluid contains. Without iron, we know the green colour or *chlorophyll* of the botanist cannot be developed; and the analogy between iron in the plant, and that metal as a blood-constituent and as a blood-tonic in ourselves, is too clear to escape notice. The staple article of my fern's food, however, next to water, proves to be a gas called *carbonic acid*. Curiously enough, this gas is that which with every breath we give out from our lungs, and which, naturally or artificially prepared as the case may be, I shall ingest at Smith's dinner party in the sparkling wines with which our host favours us, and in the milder potash water we may unite in the smoking-room to the stronger "fire-water" of the civilised unit. For us, the carbonic acid in these forms is a luxury, and not a necessity, however; by the fern and by every other green plant it is imperatively demanded. The green leaves are greedily drinking in this gas, which, if inhaled into our lungs and blood, would quickly asphyxiate us, and which, as a matter of fact, converts an ill-ventilated room into a Black Hole of Calcutta in miniature. But the green plant absorbs the carbonic acid, which, by the way, consists of so much carbon and so much oxygen. The

former element is that which the fern covets. It drinks in the gas; then, through a chemical act, splits the gas into its component carbon and oxygen; and finally, keeping the carbon to form the starch and other compounds proper to plant life, liberates and returns the oxygen to the atmosphere. Our green plant also absorbs a little of the oxygen gas of the atmosphere by way of assisting it in the chemical operations of its existence. But it is the carbonic acid which the plant especially demands, and without which ordinary plant life cannot flourish. It is only in the presence of light, however, that the green plant can treat and decompose the carbonic acid. When darkness reigns, the fern and all its green allies literally convert themselves into animals in so far as their gaseous transactions are concerned. Then they absorb oxygen and give out carbonic acid; resuming their more purely plant life and reversing this action when the light dawns and darkness disappears. To plants which, like the mushrooms and their neighbours, are not green, the presence or absence of light makes no difference. These plants habitually and at all times resemble animals, in that they constantly absorb oxygen gas, and emit carbonic acid. Last of all, our fern seems to require a little *ammonia*—by way of dessert, so to speak. Summing up the modest requirements of the plant, we may therefore say that it demands four items in its bill of fare. These items are water, minerals, carbonic acid gas, and ammonia. They are further dead or "inorganic" matters, and the fern becomes a somewhat interesting and curious being in our eyes when we reflect that it forms a type of the wondrous in plant life. From the lifeless materials that form its "food" it is able to build up the living structures which form its frame. The beauty of the leaf, the fuller glory of the flower, and the warmer radiance of the fruit, severally represent to the botanical eye merely the result of the conversion, by the forces of the plant, of the lifeless materials found in the food, into the living substance and beauty which irradiate and brighten the world.

The fern thus flourishes on the food it absorbs from the soil and the air around it. It therefore converts matter unlike itself into its own tissues and organs. If deprived of this matter (or food) it dies, and the plant presents in this respect the closest possible parallel to the life of the animal, and to that of man himself. So far as the struggle of food-getting is concerned, the lot of the fern may certainly be regarded as of an easier kind than that of the animal. For the fern finds its food at hand, so to speak, whilst the animal, as a rule, requires to search and to struggle for its pabulum. But the analogies of animal and plant life are seen to run in parallel lines when we regard the results of food-getting and of food-deprivation respectively. With food at hand, animal and plant alike flourish and grow; and through want of food both perish. It remains for us now

to endeavour to discover wherein the feeding of the animal differs from that of the plant.

Smith's invitation may aid us in our search after the essential features of the food of the animal hosts; for it can be shown readily enough that there exists a close parallel between the dietary on which Professor Caudal and his fellow-guests contrive to exist, and that which ministers to the well-being of all other animal forms. The invitation given to an animal to partake of the bill of fare which we have seen to be capable of satisfying the modest demands of the plant, would be equivalent, as Professor Huxley has remarked, to asking the former to attend a Barmecide's feast. The water, minerals, carbonic acid gas, and ammonia, on which the ordinary green plant thrives, present no attraction to the animal. Imagine that deliberate *gourmet*, Caudal, being asked to dine off such fare! We can understand the doubly effective objections—social and scientific—which would issue from the professorial mind if such a prospect were set before it. But the great scientific luminary who will enjoy Smith's dinner a fortnight or so hence, is not a wit removed from the animalcule in the superiority of his tastes and demands above those of the green plant; whilst he may discover that both animalcule and man are not so very different, after all, in the essential nature of their feeding from the fungus, or from the insect-eating vegetables.

If we sum up the materials which our dinner at Smith's will present to view, we may very readily resolve them into a variety of tolerably simple substances. Furthermore, these substances will prove to be not over-numerous. Smith's dinner may begin with *potage aux choux*, a form of liquid nutriment in favour at this season in the Smith's cuisine. For *poisson* we may, let us suppose, be presented with *sole bouillie* or *turbot*; the relevés may be Caudal's special tit-bit before mentioned, *filets de bœuf*, or even the *haricot de venaison* for which Smith's *chef* is famous. As for *entrée*, the *faisan bouilli*, or a *salmi de perdreaux*, is a likely guess, and the *rôt* and *entremets* we may set down provisionally as *bécasses ou bécassines*, and as *foie gras* and *petites coquilles*, respectively.

Now, the above list appears to represent a vast number of very different substances. Chemically, it can be shown to be resolvable into relatively few and simple elements. Smith and his *chef* together might feel surprised to discover that their elaborate *menu* was capable of being chemically shown to consist probably of three-fourths water in combination with the solids. The analysis of the *menu* might be roughly but approximately indicated if I said that at Smith's dinner we will feed upon water; minerals; certain "flesh-forming" substances containing *nitrogen* as their characteristic element; fats and oils; and starches and sugars of various kinds and qualities. The water is a necessity for animal life, as for the existence of the plant. In one form or

other, as adults, we demand several pints of this fluid per day. It enters into the composition of every fluid and tissues of our bodies, and constitutes about 87 per cent. of the bulk of the human frame. Without water we could not dissolve and digest the solids in our foods, nor could the intricate and constant chemical operations—including the production of heat—of which our bodies are the seat, be carried on without a due supply of this fluid. When one learns that the brain itself—including even the ponderous organs of Caudal and his fellow-scientists, which may be presumed to be of the "hardest" description—consists at least of between 70 and 80 per cent. of water, and that this fluid requires constant replacement, as we shall hereafter see, the importance of water as an article of diet cannot be over-estimated. Lastly, when one recollects that on water alone, and in the absence of any solid food whatever, human subjects and lower animals have lived on for 50 or 60 days, the necessity of water for animal existence at large is readily seen.

But our dinner includes, secondly, mineral matter in addition to water; and we might remark that, in so far as these two items are concerned, mankind presents no superiority of necessities or tastes over the plants. For man, as for the plant, water and minerals appear to be essential for the continuance of existence. For the perfection of our blood, we require to find iron in our food. Lime must be found in the food, that the bones and other tissues may be duly nourished. Phosphoric acid must exist in our nutriment, otherwise the nerve-substance of brain and body will be imperfectly sustained. Soda, magnesia, potash, and a host of other minerals are detected in the fluids and structures of the body; and so intimate and complex are their relations to the composition of our frame, that it appears certain that of any two minerals, one cannot replace another, both being necessary for the continuance of health and life.

I must not neglect to bear in mind, also, that, like the fungi and other non-green plants, I demand the oxygen of the air as a "respiratory food." This gas, which in Smith's well-ventilated dining-room will be supplied to me in perfection, will be inhaled into the lungs, will thence pass into the blood, and there, uniting with carbons derived from fats, starches, and like foods, will produce the heat without which life is an impossibility. Like the plant, then, it is clear we require food of a gaseous kind: the carbonic acid of my fern is replaced in humanity by oxygen. Our food, however, contains certain matters called *nitrogenous principles*, which, in the truest sense of the term, may be named "flesh-forming" substances. A very considerable part of our bodies consists of "nitrogenous" matters—that is, matters which the chemist declares are composed of the four elements, carbon, hydrogen, oxygen, and nitrogen, with traces of sulphur and phosphorus in addition. The importance of

the element "nitrogen" in the processes of animal bodies cannot be over-estimated. A high authority in foods makes the remark that "wherever living changes are carried on, nitrogenised matter is present." We further discover that the most vital substance of animal frames—the famous "protoplasm" itself—is a nitrogenous compound. A speck of this nitrogenous matter, having much the same composition as the "albumen," or white of egg itself, may constitute of itself a perfect living being. The animalcules of the stagnant pool are such jelly-specks; and the living protoplasm whereof the vital parts of our own frames are composed, exhibits a close identity of composition with the matter which constitutes the whole structure of lower life, the actual and visible entity of the higher animals, and the vital substance of the plant world at large. It can therefore be understood that with this living matter and compounds of allied nature entering into the structure of our frames, we should demand a continual supply of like substances in our food. At Smith's repast we shall obtain substances rich in "nitrogenous" foods for the renewal of our protoplasm or living tissues, from well-nigh every substance set before us. The juice of meat found, for example, in soups, the fibres of meat themselves, the gravies and sauces which decorate the viands, the milk which forms an element in the repast, the eggs and vegetables that in one form or another figure in the *menu*, and the fruits and cheese of the feast, each and all contribute a proportion of the varied "nitrogenous" substances that go to form the flesh and tissues of our bodies.

Next in order come the fats and oils. At dinner, it is hardly necessary to say, we obtain a due proportion of these substances in very varied forms. It is true we do not emulate the nutritive existence of the Esquimaux, whose dietary of blubber and fats constitutes the *summum bonum* of a life spent amid perpetual snow. But the quantity of fatty matters we daily contrive to ingest in one form or another is very considerable. From animal foods, the fats are readily obtainable, and from vegetables, oils of various kinds are also elaborated. The necessity for fat as an article of diet is seen when we learn from physiology that it not merely conserves heat—a function seen in whales and fat persons generally—but supplies material when it passes into the blood which affords our bodily fuel. Fats and oils are "heat-producers," and it is when the fat of the blood and the oxygen inhaled into that fluid from the air come into chemical combination, that heat is produced. It is needless to add that this process is being continually carried on in the human body, and to a greater or less degree in that of all other animals. The "starches and sugars" form the final materials into which we may resolve our dinner. A large variety of substances figure in the lists of chemists under the above designation. Common

observation demonstrates that we daily consume large quantities of the starches and sugars in our food. A potato, for instance, may legitimately enough be described as a mass of starch and water; rice and allied substances are three-fourths starch; from bread we obtain a large quantity of starchy matter: all vegetables, in fact, contain starch in considerable proportions. Of the various "sugars," chemically so called, the latter remark practically holds good. Even milk—nature's typical food—contains a proportion of sugar in the form of sugar of milk, or lactine; and in the muscles of animals another peculiar "sugar" is found. There can be little doubt that from sugars and starches we obtain matters which, in the economy of the body, are readily converted into fat. If Professor Caudal should ever elect to "try Banting," he will require to cut short his supply of starches and sugars as well as his daily quota of fats and oils; but the contingency of such an exercise of professorial self-denial is too humiliating to contemplate, even in the light of a theoretical possibility. That which happens to the geese of Alsace may be regarded as being illustrated in the human economy likewise. Morning and night, maize is crammed down the throat of the unfortunate bird, which starts on the experiment in a lean and meagre condition. Cramped up within a narrow space, no exercise is permitted the goose, which in about a month is killed, as the process of breathing becomes well-nigh impossible. The liver alone then weighs between one and two pounds, and the amount of fat which escapes from the tissues of the animal when it is roasted is almost incredible. Persoz of Strasburg, utilising the *foie gras* production as a physiological experiment, showed that the fattening of the goose is really due to the formation of fat from the starches and sugars of the maize on which it is fed. Thus the formation of fat, and probably also the production of heat, are the functions served within our bodies by the digestion of the starches and sugars we find in our food.

The differences between the food of the plant and that of the animal—between the nutriment of my fern and of myself—may now be appreciated. We see that whilst the plant is able, as already remarked, to build up its tissues from lifeless materials, the animal requires in addition a supply of organised or living matter. At Smith's table, besides the water and minerals we require, and in addition to the oxygen gas we respire in the air obtained from the atmosphere, we shall ingest "nitrogenous" matters derived from the animal and plant worlds. In the meats offered to us, we find "ready-made" foods, so to speak, which correspond more or less exactly in composition to our own flesh. The vegetable matters will supply us with similar materials, and in addition the starches, sugars, and fats will be purveyed us by both animal and plant

worlds. Although there are plants which, as we have seen, imitate animals in feeding upon living matter, and which thus break down the distinctions between animals and plants founded on food, yet the general course of animal and plant life remains in each case tolerably distinct. It is needless to add that, as represented at Smith's board, the human race will be shown to demand a very considerable amount of living matter, and to differ materially in this respect from the plant world at large.

The information we have thus obtained regarding the nature of the material benefits we may expect to obtain from our dinner, prefaces in a thoroughly natural fashion the question already propounded, and which asks why we eat dinner at all. Smith's dinner, and feasts of allied kind, serve to impress one with the idea that probably human nature is given to eating too much, and that repasts of less resplendent and varied character would equally well serve—as, in fact, they do actually serve in the experience of the majority—to sustain life in a perfect, or in other words a healthy, condition. But, after all, variety is both necessary and pleasant in food as in other details of life; and it is the numerical strength of Smith's dinner, so to speak, and not the quantitative aspects of the *menu*, which constitutes an attractive aspect to the cultured mind. The question "Why do we eat our dinner?" involves in its reply the whole philosophy of food-taking, and a large part of the philosophy of life. To arrive in the speediest possible manner at the conditions which render that reply possible, we must take a brief review of certain general processes which may be said to constitute the essence of the physical, and indeed of the mental part also of our existence. The dictum that life is at all times inseparably connected with changes of various kinds and degrees, forms an appropriate basis whereon to lay the foundations of the argument. The changes in question are most clearly shown in such a series of actions as those which constitute "growth." That increase of the body which takes place from the first day of its existence until maturity is reached, illustrates at least one phase of bodily alteration which we can appreciate in its connection with food and feeding. For it is obvious that from our food we must derive the material for the increase of tissues and parts. "Food," in this light, is simply matter derived from the external world, which, being incorporated with and transformed into our bodily substance, contributes to that gradual physical enlargement which characterises early life wherever existent.

That this, however, is not the only use of food becomes clear if one reflects that around Smith's dinner-table there will be assembled no one guest whose growth is still a matter of vital activity. The majority of us will present ourselves before the physiological eye as

adults whose physical belongings have long ago arrived at years of maturity. A few of us may be verging on the "sere and yellow" stage of vitality. Scientists tell us that in old age the tissues tend to lessen and to decrease in size and extent. After the age of forty years, the brain itself begins to decrease in weight, at the rate of about one ounce in ten years. Even the Professor, with his wonderful memory for facts and data, must, on this showing, have lost at least a couple of ounces of his cerebral matter, and goodness knows how much science as well—an idea which may possibly account for the fact that he grows more and more prosy and forgetful, as successive years and a multitude of dinner parties mark the course of his career. Around Smith's table, then, it seems clear our dinner will not contribute to "growth"; and it is plain that the missing brains of the scientists, and of the plain people who are in their fifties and sixties, cannot receive from Smith's choicest viands any material wherewith to recuperate their lost belongings. "Why we eat our dinner" is an inquiry that must be answered on a broader basis than is afforded by any considerations of mere growth and increase of body. We must, therefore, turn to a wider view of the vital processes, in order satisfactorily to discuss the question of the why and wherefore of food-getting and food-taking.

Such a view we may obtain when we reflect that the pursuit of life involves, at all times and under all circumstances, a serious expenditure of vital energy, and an appreciable loss of bodily and material substance. It is a grave but interesting fact of science, that no act of life, however trifling it may appear, can be performed without being attended and accompanied by a corresponding loss of energy and waste of substance. The machine that works, wears. The waste of a machine bears a strict proportion to the work it performs; and the human body, as typical of the bodies of all animals, is found to undergo wear and tear proportionate to the work discharged by its organs and parts. There is no cessation from this competition with vital waste and wear. The slightest act of life, equally with the gravest action, is attended by its relative amount of waste and loss of power and matter. The merest thought that disturbs, as by a mental ripple, the surface of the mind's organ, involves a certain amount of brain waste. The winking of an eyelid, effected by means of muscular acts, is in the same way performed only through a certain loss of substance. In each pulsation of the heart, in each rise and fall of the chest in breathing, there can be no escape from the perpetually enforced dictum of nature, that work and waste are in constant and stable fellowship throughout the entire range of living action.

We might go still further than this not unreasonable stage of life's conditions. Smith's dinner, for example, will no doubt be an enjoy-

able repast. I may flatter myself that the "flesh-forming" and "heat-producing" compounds, which physiology declares are necessary for the support of my bodily belongings, will be represented to the full in Smith's *menu*. The work of nutrition should be effected in the most agreeable manner around Smith's hospitable board, where the conversation of Caudal, for instance, may lend an additional and mental zest to the physical delights implied in the repast proper. But the physiologist steps in to inform me that even in the work of food-taking there will be expended a very considerable degree of energy. I shall be in the position of an engine which exhausts and employs its steam, even in the act of laying in water and fuel for future work. My digestion, I am informed—a work that proceeds for hours together—will necessitate a large expenditure of nerve-force, and of other forces as well. The act of converting food into a medium (the blood) adapted to nourish every tissue, is thus in itself a piece of tolerably hard work; to say nothing of the labour performed by the central engine of the circulation, the heart itself; or by the lungs and chest in the act of breathing. Life would thus seem to be a kind of process resembling that familiarly described as "burning the candle at both ends." We "rob Peter to pay Paul," in our endeavour to live wisely and well. One is reminded forcibly of that grim quotation of Huxley from Balzac's "Peau de Chagrin," by the consideration of the perpetual taking in and giving out which life seems to involve. As the magic skin shrank with every wish of its possessor, and ultimately vanished away together with the life it represented, so, to quote Huxley, "all work implies waste, and the work of life results, directly or indirectly, in the waste of protoplasm." And again: "Physiology writes over the portals of life—

Debemur morti nos nostraque,

with a profounder meaning than the Roman poet attached to the melancholy line. Under whatever guise it takes refuge, whether fungus or oak, worm or man, the living protoplasm not only ultimately dies, and is resolved into its mineral and lifeless constituents, but is always dying, and, strange as the paradox may sound, could not live unless it died."

One now begins to gain a glimpse of the fashion in which life science answers the question, Why do we eat our dinner? When we begin to conceive that the human body is, in one sense, a mere machine, which performs elaborate and complex chemical and physical work, and which, moreover, is always in action, more or less completely, we are able to understand the basis on which physiology rests its final reply concerning the philosophy involved in Smith's invitation to dinner. But to render the position of the scientist still more evident, we may inquire a little more exactly into some of the

details of bodily work—including under this latter term the mental side of matters equally with the physical aspects of life. And firstly, What, one may ask, are the proofs that this wear and tear of body represent an actual fact of existence? The candle, which disappears as it burns, only changes the form of the materials of which it consists. Chemically treated, weight for weight of waste products (gas, water, &c.), into which the candle has been resolved, could be produced, as evidence that the matter of the taper has merely undergone a change of form after all.

An analogous experiment could be performed on the human subject. If Professor Caudal could, for instance, be conceived as placed in one scale of a balance—calculated to contain safely the ponderous frame of that celebrated scientist—and a counterpoise in the shape of a series of accurately adjusted weights placed in the other scale, we might be able to determine with exactitude, first, that the Caudal frame grew lighter as the eminent student of physiology worked; and, secondly, that, as the Professor refreshed and renewed his inner man, the scientist in his scale would once again fall to the balanced condition. If Caudal took to lifting loads, heaving wood, or drawing water in his scale, we should find that the loss of weight which he had previously exhibited would be increased proportionately to the exertion his physical labours had entailed. To bring himself and his scale back to equilibrium, he would require simply to eat the requisite amount of food. Possibly if Caudal, sitting in his scale, occupied his brain with the solution of some of those knotty problems which a select audience at Burlington House occasionally meets to discuss in his company, we might not see the Caudal scale rise with loss of weight so distinctly and rapidly as if the Professor indulged in mechanical pursuits. But that the mental work would entail waste, an expenditure of force, and a loss and lightening of the Professor's frame, there can be no question. The mental work simply differs from the bodily labour in that its waste is, if anything, of a more subtle character than that which results from physical toil; and, one might also add, in that the mental waste is not quite so readily made good and repaired as the bodily wear and tear. If Caudal's income in the shape of food were given him in excess of the expenditure of his substance in work, we should find that his scale would alter daily or hourly, but that it would constantly preponderate over the other scale, and never tend to approach the beam. If the Professor were placed on diminished allowance, we should, on the contrary, find that, like a weighty "spirit medium," he would remain constantly in the air, whilst the weighted scale would drop by comparison. But work and repair being equal, we should note that Caudal simply rose and fell as his substance was used up in the work he performed, and as he received his pabulum, respectively.

The consideration, however, crops up before us, that if the foregoing conclusions be correct, we should find our subject in the scales to remain stationary so long as he performed no work at all. The contention is a natural one; but, unfortunately, it has no physiological standing. There is no period of day or night during which cessation from work is possible to the body. If we suppose that the Professor in the scales consented to trouble himself neither about to-day nor concerning to-morrow, and to allow his muscles as well as his cerebral organ to remain as thoroughly passive as might be, he would still remind us of breakfast, lunch, and dinner; and, apart from habit altogether, would feel perfectly ready and willing to join us at table when the "joyful sound" of gong or bell reached his ears. Nor would he be at any loss to reply to the obvious remark that, as he had done no work, he could have no reasonable expectation of participation in the delights of the table. He would require us to note, firstly, that he had been working, even while resting; secondly, that this work was unavoidable; and thirdly, that from its serious nature it necessitated speedy repair. The Professor's heart—for, contrary to the opinion of the female portion of his acquaintance, the eminent scientist possesses such an organ—can be shown to perform in each twenty-four hours of his existence an amount of work which can be legitimately termed of prodigious extent. Calculations of very exact nature have been made regarding the work done by the central organ of the circulation. The heart is a hollow muscle; hollow, to allow blood to pass through its chambers, and a muscle, that it may contract to expel the blood forth into the vessels. The heart's work is therefore as purely muscular work as is the lifting of weights or the movements of walking. Now, the "unit of work," as the basis of calculating the amount of labour expended in any given action, is an expression which, plainly stated, may be taken to mean that amount of energy (or "power of doing work") required to raise a unit of weight (1 lb.) through the unit of height (1 foot).

The heart is composed of four compartments or chambers. Two are "auricles," which receive blood from body and lungs respectively, and which propel the blood each into the larger chamber (or "ventricle") with which the auricle of each side is in free communication. If the weight of the blood which is expelled by the sharp contraction of each ventricle is multiplied by the height to which the blood rises in a tube placed in communication with the outlet of the ventricle, we obtain in the result the work done by each of these larger chambers of the heart. It has been found that the height to which the blood is sent in the tube is about nine feet. The weight of the blood expelled at each contraction of the left ventricle of the heart is about four ounces. The multiplication of these numbers, therefore, gives us $2\frac{1}{4}$ foot-pounds—that is, a force capable of raising

that number of pounds one foot high—as the work performed at each contraction of the left ventricle. The right ventricle's work measures only one-third that of the left; the right side of the heart being less powerful than the left, and being occupied with driving blood simply to the lungs, whilst the left side propels blood through the entire system. The addition of the work of right and left sides, therefore, gives us three "foot-pounds" as the total work of the heart at each beat or contraction. But in an adult person of Caudal's *physique* there are performed at least some seventy-five or seventy-six such contractions per minute. At this rate, in twenty-four hours the heart must perform a startling amount of work. If we could gather all the force expended by the human heart in twenty-four hours into one huge lift, it would suffice to raise at least 120 tons weight one foot high. After such a revelation, it would be easy for us to accept Caudal's hunger and thirst as the perfectly rational symptoms of a lazy man. With the fact at hand of a bodily pumping engine constantly at work within his frame, he would require no further proof of his right to replenish the wear and tear of his body by regular attendance at meals. The idle man must needs eat and drink—for common idleness has at least a physiological justification at its back in the shape of the aphorism that whatever the hands find to do, the bodily organisation knows no rest or cessation from its labour and its toil.

It can be shown that the work of the heart is not the only labour which the ordinary processes of life entail. The function of breathing is practically as incessant in its operation as that of the heart. The rise and fall of the chest include, and are effected through, the work of a multiplicity of structures, such as ribs, chest-muscles, midriff, and lungs. When we read that there pass in twenty-four hours through the lungs of an adult at rest some 686,000 cubic inches of air—a quantity increased in the same period to 1,568,390 cubic inches in the hard-working subject—we may judge that the work and labour of breathing may fitly enough be ranked with that of the heart in respect of its magnitude. There exists a large amount of natural resistance offered by the elastic nature of the lungs and chest, and which has to be overcome by the muscles employed in breathing. It has been shown that the force which has to be overcome by these muscles in the act of breathing in 200 cubic inches of air exceeds 450 pounds. In ordinary breathing, the elastic force we require to overcome equals at least 170 pounds. With these details at hand, there is little need to further emphasise the fact that the stillest of lives is in reality a long spell of continuous work. In twenty-four hours the muscles of breathing alone, perform an amount of work equal to the raising of twenty-one tons one foot high. Adding this amount to the force exerted by the heart, we may understand that

even the quiet moments of our lives are attended by and carried on through work of a very severe character; and this even when the almost endless work of the brain in thought, and of the nerve-centres in controlling the bodily actions, is entirely set aside and overlooked in our calculation.

Returning for a moment to Caudal, whom we left in the scales, we may be required to specify the exact form in which the bodily substance of the subject experimented upon has disappeared in the acts and processes of life. Briefly stated, so much of our material substance is given off from skin and lungs, for example, in the form of water; part is excreted in the shape of carbonic acid gas, which thus becomes available as food for green plants; and part of the wear and tear is likewise given off in the form of heat, a curious substance called "urea," and as ammonia and mineral matters. In other words, our bodies, as the result of the work they perform, are perpetually being dissipated into so much heat, water, carbonic acid gas, and other substances. The animal frame is constantly breaking down into these inorganic matters, and is thus at once finding a lower level of existence and supplying the plant world with the matters from which the life of the vegetable kingdom will evolve new growths and fresh generations. Well might Erasmus Darwin write—

> Hence, when a monarch or a mushroom dies,
> Awhile extinct the organic matter lies,
> But as a few short hours or years revolve,
> Alchemic power the changing forms dissolve;
> Emerging matter from the grave returns,
> Fills new desires, with new sensation burns.

If it is true that "in the midst of life we are in death," it is no less true that from the physiological charnel-house into which living beings are perpetually doomed to pass, new forms take their origin. These are fed by the matter which, having done duty in living bodies, is, after a period of so-called decay, woven anew into the textures of succeeding generations of animals and plants.

The answer to the question with which we began our scientific journeyings should now loom plainly enough ahead. We eat our dinner because, in the food of which that meal consists, we expect to find materials capable of replacing those we have lost in the acts and processes of life. "Food," in this view, from dry bread to Smith's choicest dainties, is only matter which the body demands for its sustenance and support; and the perfect diet is simply that which affords us the most complete epitome of our bodily belongings in most condensed form, and in a shape susceptible of ready conversion, by digestion, into ourselves. We eat, then, because we waste, and we waste because we work. There is no escape from the continual wear and tear which besets us. We receive so much

food as income, and we exert so much force and give off waste matters as expenditure; our profit in this transaction consisting of the "energy" or power of doing work we obtain from our food. It is true that we eat to live; it would be a truer statement if we said that we eat to work. We begin our physiological career with work, and our dinners are the consequence of our exertion.

There is, after all, a considerable savour of an admirable social philosophy in this view of matters. The knowledge that these frames of ours periodically make reasonable and natural demands, through hunger and thirst, for the wherewithal of life and work, seems to lead to the plain conclusion that they deserve good and wise treatment. There can be no hesitation in endorsing the statement that living well means, other things being equal, living long. Smith's dinner looming in the distance becomes thus invested with a fresh charm in one's eyes, and the charm is all the more æsthetic and satisfying because it is scientific. I shall feel equal to the task of looking benignantly even at Caudal whilst I listen to the platitudes wherewith he entertains us at the festive board. The Professor represents a science which has administered many grains of comfort to the *bon vivant*, and which does not add any exceptional *granum salis*—except to assure us that chloride of sodium (otherwise common salt) is a necessary component of the gastric juice, and one without which—— But we are becoming too scientific, and one has already found the true justification of a good dinner. This is all. No; I had almost forgotten Smith's invitation. Now for its reply: "Yes, with the greatest of pleasure;" and may good digestion wait on appetite.

THE END.

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